MANAGEMENT PLAN

FOR

NITROGEN OXIDES (NOx)

AND

VOLATILE ORGANIC COMPOUNDS (VOCs)

FIRST EDITION

DRAFT
MARCH 1990

For Stakeholder Consultation

Federal / Provincial Long Range Transport of Air Pollutants Steering Committee

Comité directeur fédéral / provincial sur le transport à distance des polluants atmosphériques

Province of British Columbia
Ministry of Environment and Parks

Gouvernement du Québec
Ministère de l'Environnement

Alberta
ENVIRONMENT

New Brunswick
Department of the Environment

Saskatchewan
Environment and Public Safety

Community & Cultural Affairs

Manitoba
Environment and Workplace Safety and Health

Nova Scotia
Department of the Environment

Environment Ontario

Province of Newfoundland
Department of the Environment

Canada

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FOREWORD

This draft Management Plan for Nitrogen Oxides (NOx) and Volatile Organic Compounds (VOCs) is very preliminary in nature. It is intended for review by a wide cross-section of stakeholders during March and April, 1990, and to provide a basis for discussion at a multi-stakeholder workshop during April 18-20, 1990.

All aspects of this document are subject to change in the final plan. This includes the scope, format, approach, content and timing of the plan. The plan will be finalized during May and June, 1990 taking into consideration the views of stakeholders.

The plan has been prepared in a very short time frame. It may contain some inaccuracies and warrants considerable editorial improvement. Readers should bear this in mind. Hopefully, it contains the basic material to foster discussion and debate that will lead to a comprehensive, effective final management plan for submission to CCME in October, 1990.

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ACKNOWLEDGMENTS

List of Symbols and Abbreviations

CCME	Canadian Council of Ministers of the Environment
CFCs	Chloroflorocarbons
CO_2	Carbon dioxide
DSM	Demand Side Management
EPA	Environmental Protection Agency (U.S.)
g/BHP-hr	Grams per break horsepower per hour
g/mi	Grams per mile
HDV	Heavy Duty Vehicle
I & M	Inspection and maintenance
Km	Kilometer
LDV	Light Duty Vehicle
LFV	Lower Fraser Valley
MMBTU	Million BTU (British Thermal Unit)
Ng/J	Manograms per joule
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
N_2O	Nitrous Oxide
NOx	Nitrogen Oxides
O_3	Ozone
ppb	Parts per billion
ppmv	Parts per million in volume
ROM	Regional Oxidants Model
SJA	Saint John Area
VOC	Volatile Organic Compounds
WQC	Windsor-Quebec Corridor

SUMMARY OF DRAFT PLAN

The Canadian Council of Ministers of the Environment (CCME) requested in October 1988, that a management plan be developed for the control of nitrogen oxides (NO_x) and volatile organic compounds (VOCs). The plan was to be developed in consultation with interested stakeholders and delivered to CCME by October, 1990.

This document contains a draft of the NO_x/VOC Management Plan. As part of the ongoing stakeholder consultation process, it will undergo comprehensive stakeholder review in the months of March and April, 1990. After this review it will be modified as required, taking into consideration the views of stakeholders, and finalized for submission to CCME prior to its annual fall meeting in October, 1990.

This NO_x/VOC Management Plan is labelled "First Edition". Subsequent editions will be prepared periodically over the next 10 years to account for new information, concerns and opportunities. Adjustments may also have to be made in future editions to account for measures being taken in other related programs, such as for CO_2 control, that may affect NO_x and VOC emissions.

Nature of Concern

The NO_x/VOC Management Plan has been developed in recognition of the fact that there are serious NO_x and VOC related health and environmental concerns in parts of Canada today. One of these is the elevated levels of groundlevel ozone, a component of urban smog. Ozone is formed by a photochemical reaction between NO_x and VOCs in the presence of sunlight.

Ozone above certain concentrations in the ambient air could adversely affect human health and vegetation. Human health effects include a decrease in lung function and premature aging of the lung. Vegetation damage is usually in the folior damage which affect growth and productivity.

More than half of all Canadians are exposed regularly in summer months to ambient air ozone concentrations that are known to cause adverse health effects. These levels are often more than twice the Canadian "maximum

acceptable" air quality objective for ozone. During severe ozone episodes, such as those that occurred in 1988, people in some major Canadian cities have been advised to stay indoors and limit outdoor physical activity. Crop damage in Ontario alone from elevated ozone levels throughout the entire summer growing season is estimated at up to $70,000,000 per year. There is known damage to foliage of forest species but no firm evidence on loss of production.

International Actions

Elevated ambient air ozone concentrations are recognized around the world as a serious health and environmental problem. The concerns stem from both the observed long-term buildup of background ozone levels in the western hemisphere, and the magnitude of short duration high concentration exposures during peak ozone "episodes" that occur regionally. Many nations are in the process of establishing agressive new ground level ozone reduction programs.

Countries have also joined forces in setting some common targets for ozone reduction. Canada and 24 other nations signed an international protocol in 1988 committing nations to a freeze in NO_x emissions at the 1987 level, the application of best available technology economically achievable to new sources, and the establishment of further measures to solve NO_x-related environmental problems by 1996. Canada is now participating in the negotiation of a VOC protocol.

Ozone and its precursor pollutants, NO_x and VOCs, can be transported long distances in the atmosphere. While domestically produced NO_x and VOC emissions are an important contributor to Canadian ground level ozone problems, in parts of central and eastern Canada imported ozone, NO_x and VOCs from the United States is the dominant factor. Efforts are being made to establish a transboundary air quality agreement with the United States which would focus first on sulphur dioxide, but under which ozone, NO_x and VOCs, could eventually be included.

Steps are being taken in the United States which should result in reduced transboundary flow of ozone, NO_x and VOCs into Canada over the next decade.

The proposals for amending the U.S. Clean Air Act that are now being considered by the U.S. Congress call for sigrificant reductions in emissions of both NO_X and VOCs by Year 2000.

Purpose and Scope of the Plan

The NO_X/VOC Management Plan has been designed to address the two primary objectives laid down by the CCME in October, 1988. These are that the plan should:

1) solve our domestic NO_X and VOC related environmental problems;
2) meet our international obligations.

The focus of the plan is on reduction of ground level ozone. Other concerns with NO_X and VOCs, such as direct toxic effects of some VOC compounds, are secondary considerations in the plan. These concerns are being addressed under other programs. Direct toxic effects, for example are being dealt with through the Priority Substance List of the Canadian Environmental Protection Act and various provincial programs for control of toxic air pollutants.

The plan has been developed with consideration of other related air pollution control programs, including the Canadian acid rain control program and anticipated future programs for control of greenhouse gas emissions. It was recognized at the outset that in addition to emission source control measures, energy conservation and lifestyle change initiatives, which are likely to be a primary thrust of a greenhouse gas control program, would also be necessary elements of a NO_X and VOC management plan if it was to fully resolve our groundlevel ozone problems.

Preparation of the plan has been guided by principles of allocating emission reductions developed through a comprehensive stakeholder consultation process. These principles include such items as equity and fairness, the need to prevent future air quality problems as well as resolve existing ones, the avoidance of undue restriction on technology innovation and choice of emission reduction options, and the ability of measures to solve more than one environmental problem. The complete set of principles is listed in the plan.

Elements of the Plan

The NO_X/VOC Management Plan First Edition contains 61 specific initiatives for reduction of NO_X and VOC emissions and 20 study initiatives designed to provide information for preparing a second edition of the plan in 1994. The NO_X control, VOC control and study initiatives are listed in Tables A, B and C respectively.

Of the 61 emission reduction initiatives, 23 deal with NO_X and 38 with VOCs. For both NO_X and VOC control, initiatives are divided into three categories:

- energy conservation and product control;
- consumer choice and lifestyle; and
- source control.

The Plan initiatives are approximately equally divided between those that are national in scope and those that are region specific. Implementation of the initiatives will be shared by federal, provincial and municipal jurisdictions.

The initiatives have been designed on the premise that both NO_X and VOC reductions are needed to resolve and prevent ground level ozone problems in Canada. Control of both NOx and VOCs is important for reducing peak ozone levels in urban areas. In rural areas, the reaction for ozone formation is usually NO_X limiting, requiring that NO_X levels be reduced if reductions in ground level ozone concentrations are to be achieved.

Effectiveness of the Plan

The plan, when fully implemented, will achieve the following:

- NO_X and VOC emissions nationally in year 2005 that are 16% and 19% respectively below current (1985) emission levels, with reductions of about 30% in key ozone problem areas.

TABLE A - NO_x/VOC MANAGEMENT PLAN - NO_x REDUCTION INITIATIVES

Initiative		Control Instrument: Type	Control Instrument: Delivery Date	Control Instrument: Effective Date	Reference Pages in Plan
(a) NATIONAL					
Energy Conservation and Product Control					
N101	Power utility DSM, energy perf. stds	DSM Plans	31 Dec. '93	2000/2005	69, 82
N102	Energy efficiency in industry	Code or G.L.	92/93/93/95	1995-1998	69, 84
N103	Energy audits by industry	Audit Plans	31 Dec. '92	1993	69, 86
N104	Energy efficiency in buildings	CSA Standards	31 Dec. '94	1996	69, 86
Consumer Choice and Lifestyle					
N201	Public Education - Driving/Alt. Transport	Media Campaign	91-99	1991-1999	69, 87
N202	Public Education - Energy Conservation	Media Campaign	91-99	1991-1999	69, 87
Source Control					
N301	Light Duty Vehicle NO_x limit - 0.4 g/mi	Federal Regulation	31 Dec. '91	1994/1996	70, 88
N302	Heavy duty vehicle NO_x limits - 5/4 g/BHP-hr	Federal Regulation	31 Dec. '92	1995/2000	70, 88
N303	Const. diesel engine NO_x limit - 6g/BHP-hr	Federal Regulation	31 Dec. '95	1998	70, 89
N304	Cap on rail transport NO_x at 115 kt/yr	Reporting Schedule	31 Dec. '91	1992	70, 90
N305	NSPS - Power plants	CEPA Guideline	31 Dec. '92	1995/2000	70, 91
N306	NSPS - Industrial Boilers	CCME Guideline	31 Dec. '91	1994	70, 93
N307	NSPS - Gas Turbines	CCME Guideline	30 June '92	1994	71, 94
N308	NSPS - Compressor Engines	CCME Guideline	31 Dec. '91	1993	71, 95
(b) REGIONAL (See Plan for Regional Application)					
Energy Conservation and Product Control					
N401	Urban Transportation Management	Management Plans	30 June '92	2000	71, 96
Consumer Choice and Lifestyle					
N501	Restricted Activity Days	Mun. Plans/Criteria	31 Mar. '93	1993	71, 96
N502	Highway speed reduction	Provincial Programs	31 Dec. '92	1993	71, 97
N503	Public Education-Highway speeds	Prov. Media Campaign	92-99	1992-1999	71, 98
Source Control					
N601	Motor Vehicle Inspection & Maintenance (I&M)	Provincial Programs	31 Dec. '93	1994	72, 98
N602	Retrofit - Existing Power Plants	Prov. Limits/Schedules	31 Dec. '92	1997	72, 99
N603	Retrofit - Existing Industrial Boilers	Prov. Limits/Schedules	31 Dec. '93	1997	72, 101
N604	Retrofit - Existing Iron & Steel Mills	Prov. Limits/Schedules	31 Dec. '93	1997	72, 101
N605	Retrofit - Existing Refinery Processes	CCME Guideline	31 Dec. '93	1997	72, 102

TABLE B - NOx/VOC MANAGEMENT PLAN - VOC REDUCTION INITIATIVES

Initiative		Control Instrument: Type	Control Instrument: Delivery Date	Control Instrument: Effective Date	Reference Page in Plan
(a) NATIONAL					
Energy Conservation and Product Control					
V101	Solvent Content of Paints	CCME Guideline	31 Dec. '92	1995/2000	74, 103
V102	Interior Oil-Base Paints to Water-Base	CCME Guideline	31 Dec. '92	1997	74, 104
V103	Solvent Content of Glues/Adhesives	CCME Guideline	31 Dec. '93	1997	74, 104
V104	Summer Ban-auto Windshield Wash	CCME Request	1991	1991	74, 105
V105	Solvent Content of Consumer Products	CCME Action Plan	31 Dec. '92	1993/1995	74, 105
V106	Ozone Episode Ban-pesticide Appl^{n}	Municipal ByLaw	31 Dec. '92	1993	74, 106
V107	Control for General Solvent Use	CCME Action Plan	31 Dec. '94	2000	75, 107
Consumer Choice and Lifestyle					
V201	Public Education - Driving/Alt. Transport	Media Campaign	91-99	1991-1999	75, 106
V202	Public Education - Energy Conservation	Media Campaign	91-99	1991-1999	75, 107
Source Control					
V301	Light Duty Vehicle VOC Limit - 0.25 g/mi	Federal Regulation	31 Dec. '91	1994/1996	75, 107
V302	Vapour Balance Equip. - New Gasoline Terminals	CCME Guideline/Code	31 Dec. '90/91	1992/1993	76, 108
V303	Vapour Recovery Equip. - New Service Stations	CCME Code	31 Dec. '90	1992	76, 108
V304	NSPS - Volatile Liquid Storage Tanks	CCME Guideline	31 Dec. '91	1993	76, 109
V305	NSPS - Chemical Plant Processes	CCME Guideline	31 Dec. '92	1994	76, 110
V306	NSPS - Plastics Processing	CCME Guideline	30 June '93	1995	76, 110
V307	NSPS - Pulp & Paper Sulphate Process	CCME Guideline	31 Dec. '92	1994	77, 111
V308	NSPS - Comm/Ind. Paint Application	CCME Guideline	31 Dec. '92	1994	77, 111
V309	NSPS - Printing Ink Manufacturing	CCME Code	30 June '93	1994	77, 112
V310	NSPS - Comm/Ind. Printing	CCME Code	30 June '93	1994	77, 112
V311	NSPS - Comm/Ind. Degreasing	CCME Code	30 June '94	1995	77, 113
V312	NSPS - Dry Cleaning	CCME Code	31 Dec. '93	1995	77, 114
(b) REGIONAL (See Plan for Regional Application)					
Energy Conservation and Product Control					
N401	Urban Transportation Management	Management Plans	30 June '92	2000	77, 114
Consumer Choice and Lifestyle					
V501	Restricted Activity Days	Mun. Plans/Criteria	31 Mar. '93	1993	77, 115

TABLE B - NOx/VOC MANAGEMENT PLAN - VOC REDUCTION INITIATIVES (Cont'd)

Initiative		Control Instrument			Reference Page in Plan
		Type	Delivery Date	Effective Date	
Source Control					
V601	Motor Vehicle Inspection and Maintenance (I&M)	Provincial Programs	31 Dec. '93	1994	78, 115
V602	Gasoline Volatility Limit-9.0 psi	Provincial Regulation	31 Dec. '91	1992	78, 115
V603	Retrofit Vapor Bal. - Exist. Gas Terminals	CCME Code	31 Dec. '91	1993	78, 116
V604	Retrofit Vapour Bal. - Existing Serv. Stations	CCME Code	31 Dec. '90	1993	78, 116
V605	Vehicle Refuel Vapour Balance (Stage II)	CCME Code	31 Dec. '91	1993/1995	78, 117
V606	Fugitive Emission Control - Refineries	CCME Code	31 Dec. '91	1993	78, 117
V607	Retrofit - Chemical Plant Processes	Prov. Limits/Schedule	31 Dec. '92	1996	78, 118
V608	Fugitive Emission Control - Chemical Plants	CCME Code	31 Dec. '91	1993	78, 119
V609	Retrofit - Existing Plastics Processing	Prov. Limits/Schedule	30 June '93	1996	79, 119
V610	Retrofit - Existing Pulp & Paper Sulphate Proc.	Prov. Limits/Schedule	31 Dec. '93	1997	79, 120
V611	Retrofit - Existing Ink Manufacturing	Prov. Limits/Schedule	30 June '93	1996	79, 120
V612	Retrofit - Existing Comm/Ind. Printing	Prov. Limits/Schedule	30 June '93	1996	79, 121
V613	Retrofit - Existing Comm/Ind. Degreasing	Prov. Limits/Schedule	31 Dec. '93	1997	79, 121
V614	Retrofit - Existing Dry Cleaning	Prov. Limits/Schedule	31 Dec. '93	1997	79, 122
V615	Retrofit - Existing Wood Waste Burning	Prov. Limits/Schedule	31 Dec. '92	1991/1995	79, 122

TABLE C - NOx/VOC MANAGEMENT PLAN - STUDIES AND INVESTIGATIONS FOR SECOND EDITION

Study Initiative		Reference Agencies	Date	Reference Pages in Plan
Emission Inventories and Forecasts (S100 Series)				
S101	Streamline Emission Inventories with Maximum 1 Year Lag Time.	Env. Canada All provinces	1993	80, 123
S102	Update National Emission Forecast Annually, Extending to 2010.	Env. Canada All provinces	Annual	80, 123
S103	Emission Surveys for the Pulp and Paper and Wood Transformation Sectors.	Env. Canada NB, Que, Ont, BC	1991	80, 124
S104	More Accurate Data Base on Emissions From Products Containing Solvents	Env. Canada All provinces	?	80, 124
S105	Number and Usage Rates of Off-road Vehicles.	Env. Canada	?	80, 125
S106	Inventory Data for the WQC to Facilitate Oxidants Modelling.	Env. Canada Que, Ont	31 Dec. '91	80, 125
Ambient Air Quality and Modelling (S200 Series)				
S201	Analysis of Available Ambient Air Monitoring Data.	Env. Canada NB, Ont, Que, BC	1991	80, 126
S202	Better Information on the Transboundary Flow of NO_x, VOCs and Ozone.	Env. Canada NB, Ont, Que, BC	31 Dec. '91	80, 126
S203	Refined Meteorological Data Sets to Facilitate Oxidants Modelling.	Env. Canada	30 June '91	80, 127
S204	Set Up and Run Appropriate Scale Oxidants Models for the LFV and WQC.	Env. Canada Ont, Que, BC	1991/1993	80, 127
Technologies, Control Options and Costs (S300 Series)				
S301	Refine Cost Estimates for VOC Emissions From Major Sources (organic chemical plants, etc.).	Env. Canada Ont, Alta	1991	80, 128
S302	Current VOC Emission Controls in Plastics, Pulp and Paper and Wood Transformation.	Env. Canada	1991	80, 128
S303	R&D on Advanced Combustion and NO_x Emission Control Technologies.	Env. Canada EMR	1991-1995	81, 129
S304	Current Control and Product Substitution in All Major Solvent Use Categories	Env. Canada Ont, BC	30 June '91	81, 129
S305	Control and Product Substitution Options for Major Solvent Use Categories.	Env. Canada Ont, BC	30 June '91	81, 130

TABLE C - NOx/VOC MANAGEMENT PLAN - STUDIES AND INVESTIGATIONS FOR SECOND EDITION (Cont'd)

Study Initiative		Reference Agencies	Delivery Date	Reference Pages in Plan
S306	Implications of Greenhouse Gas Control Program for NO_x and VOC Emissions.	Env. Canada EMR, All provinces	Link to GHG Program	81, 130
S307	Analyse Canadian Transportation Network to Determine Potential to Reduce NOx, VOC and CO_2 Emissions by Intermodal Shifts.	Transp. Canada EMR	31 Dec. '91	81, 131
U.S. Emission Control (S400 Series)				
S401	Analyze New U.S. NO_x Control Program for NO_x Reductions in Selected Regions.	Ont, Que, BC	1991/1993	81, 131
S402	Analyze U.S. State Implementation Plans (SIPs) in Selected Ozone Non-attainment Areas.	Ont, Que, BC	31 Dec. '92	81, 132
S403	Analyze Any Plans by Detroit to Develop a Stable Methanol Supply.	Ont.	31 Dec. '91	81, 133

- a reduction in peak ozone levels ranging from 15 to 35 percent in most areas of concern with respect to elevated summertime ozone concentrations. (There are some areas near the United States border where no reductions will occur from Canadian action alone eg. Windsor, Long Point).

- a reduction in hours above the "maximum acceptable" ozone concentration (82 ppb) ranging from 30 to 75 percent in most areas of primary concern. (Again, no significant change in some areas near the United States border).

- modest reductions (less than 10%) in growing season mean ozone concentrations. Much greater reductions in NO_x emissions would be needed to further reduce growing season mean ozone concentrations.

- major reductions (15 to 60%) in some sources of VOCs which are of concern because of their toxicity as well as their ozone forming potential.

- a reduction in emissions of carbon dioxide (CO_2), of concern because of its contribution to the greenhouse effect, of approximately 6 percent from the level projected for 2005.

- consistency with Canada's international obligations under the United Nations Economic Commission for Europe (ECE) NO_x Protocol signed by Canada on October 31, 1988.

    - NO_x emissions under the plan will be about 5% below the 1987 level by December 31, 1994, the date specified for a freeze at the 1987 level.

    - The plan calls for national emission standards for major new mobile and major new stationary source categories as specified in the protocol.

- consistency with Canada's commitment not to increase the transboundary flow of NO_x and VOCs into areas of the United States already experiencing ozone or acid rain problems.

    - the plan will result in decreases in transboundary flows of NO_x and VOCs to the United States of 25 to 35 percent in areas of potentially significant transboundary flow. (Windsor-Quebec Corridor, Lower B.C. Mainland).

Cost of the Plan

The plan will result in significant costs to governments and industry, and is dependent to some degree on consumer adaptation and response to the need for lifestyle changes to improve and conserve the quality of the environment.

Two kinds of costs will be incurred. The first, is the cost of conducting investigations, consulting with stakeholders and developing the regulatory instruments to put the plan in place. Over a 5-year period from 1990-1995 this will cost $90 million, exclusive of industry "participation" costs in the regulatory processes.

The second form of cost that will be incurred by implementing the plan is the cost of measures that will be taken to reduce NO_x and VOC emissions. These "emission reduction costs" are estimated to be $630 million per year by 2005. They are split as follows:

- $280 million/year for NO_x control
- $350 million/year for VOC control

Costs will begin to be incurred by NO_x and VOC source sectors in the early 1990s and increase gradually through to 2005.

It should be noted that the costs of NO_x and VOC reductions due to energy conservation and product substitution measures are estimated to be zero. Most analyses conclude that such measures actually result in economic benefits. Economic benefit from these measures would offset some of the "emission reduction costs" incurred by industry, which invariably are passed on to the consumer.

Provision for Update

The plan provides for periodic update and revision to account for new information on effects, new opportunities to reduce emissions, and the influence of other environmental program, such as programs to reduce greenhouse gas emissions. Second and third editions of the Plan are scheduled for 1994 and 1997 respectively.

Endorsement [Statement to be Modified Accordingly in Final Version of Plan]

This plan is endorsed by the Canadian Council of Ministers of the Environment (CCME). Federal and provincial Environment Ministers will seek the necessary cooperation of municipal and regional governments as well as other government departments such as Energy, Transport, Industry and Health, to implement the plan.

I. INTRODUCTION

The Canadian Council of Ministers of the Environment (CCME) announced, on October 6, 1988, that a federal/provincial plan would be developed for the further management of emissions of nitrogen oxides (NO_x) and volatile organic compounds (VOCs). The plan was to have two primary objectives:

1) to resolve existing NO_x and VOC related environmental problems in Canada

2) to meet Canadian international obligations relating to NO_x and VOCs.

The task of developing the plan was assigned to the Federal/Provincial Long Range Transport of Air Pollutants (LRTAP) Steering Committee. CCME instructions to the committee were three fold:

i) the management plan should be completed in two years and delivered to CCME by October, 1990.

ii) energy efficiency and energy conservation measures should be an integral part of the plan.

iii) the committee should consult with all stakeholders in developing the management plan

This document constitutes the First Edition of the Management Plan. Scheduled updates to the plan recommended for 1994 and 1997 will result in second and third editions in those years. Hereafter throughout this document, the NO_x/VOC Management Plan - First Edition will be referred to simply as "The Plan".

While NO_x and many VOCs are pollutants in their own right, the focus of the plan is on ground level ozone (smog), a secondary pollutant formed by a photochemical reaction between NO_x and VOCs in the presence of sunlight. The plan may help resolve other environmental concerns with NO_x and VOCs, such as direct toxic effects of certain VOCs, but it is not specifically designed for that purpose. Also, some NO_x and VOC control measures could conceivably

result in decreases or increases in emissions of other pollutants, such as carbon dioxide and sulphur dioxide. The implications of the plan for other pollutants and the consistency of the plan with the objectives of other air pollution control programs, such as those for the control of acid rain and greenhouse gas emissions, were considered in a general sense in preparing the plan.

The plan development program involved a very comprehensive stakeholder consultation process. This process was used to establish principles and guidance for developing the plan, to identify information gaps and set the mechanisms in place to resolve them to the degree possible within the established time frame, and to provide an organized framework for stakeholder review of a draft version of the plan prior to its finalization and submission to CCME.

Preparation of the plan also involved an extensive review and analysis of information, and in some cases the development of new information, on NO_x, VOCs and ground level ozone (O_3). This included information on health and environmental effects, the nature of ground level ozone problems in Canada, emission reductions needed to resolve existing problems, current and future emissions of NO_x and VOCs, and NO_x and VOC management opportunities.

Part of the information was assembled as a result of the stakeholder consultation process, through which a series of Work Groups were established to examine selected topic areas. Reference is made to the Work Group reports throughout the plan. They will provide essential information for interpreting various aspects of the plan. They will also be useful in implementing the plan after it comes into effect and in some cases identifying NO_x and VOC management opportunities that are beyond the scope of the plan but could be pursued by industries, organizations or individuals on a voluntary basis.

The plan contains a range of NO_x and VOC reduction measures and strategies. These include emission limits for new and existing facilities, targets for fuel economy and product substitution, energy performance standards, and public education initiatives to increase public awareness and stimulate voluntary actions. The plan contains a schedule for implementation of the measures identified with target dates during the period 1991-2000 for measures to become effective. In addition to NO_x and VOC management measures identified, a number of actions are proposed to evaluate the plan and provide the information necessary to produce a Second Edition in 1994.

II. NATURE OF THE PROBLEM

II.1 Summary of Concerns

Some of the environmental and health concerns associated with NO_x and VOC emissions are illustrated in Figure 1.

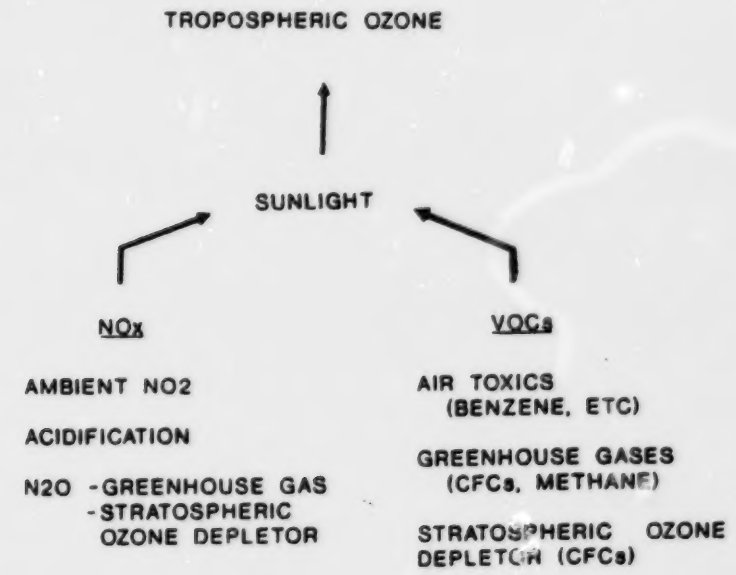


FIGURE 1 NO_x AND VOC RELATED ENVIRONMENTAL AND HEALTH EFFECTS.

In addition to their contribution to the formation of the secondary product ozone (O_3), both NO_x and VOCs are pollutants in their own right with potential to cause other adverse environmental and/or health effects than those that are ozone-related.

II.2 Sources and Forms of NO_x and VOCs

a) Nitrogen Oxides

Nitrogen oxides (NO_x) can exist in several forms in the atmosphere. Nitrogen oxide emissions from the combustion of fossil fuels, which contributes more than 95% of all NO_x emissions in Canada, are mostly in the

from of nitric oxide (NO). Small quantities, usually less than 10%, are in the form of nitrogen dioxide (NO_2), and in the case of stationary fuel combustion, a very small fraction, usually less than 1%, can be emitted in the form of nitrous oxide (N_2O).

Once in the atmosphere, nitric oxide is rapidly converted to NO_2 and other nitrogen species through oxidation and other chemical reactions. These species include particulate nitrate, nitric acid (HNO_3), nitrous acid (HNO_2), peroxy acetyl nitrate (PAN) and numerous other inorganic and organic nitrogen compounds. It is also suspected that small amounts of NO may be converted to N_2O in stationary source plumes containing sulphur compounds, although this area is still being investigated.

b) Volatile Organic Compounds

Volatile organic compounds (VOCs) are released during combustion, from various industrial processes, and from evaporation of liquid fuels, solvents and organic chemicals. A small fraction of the VOCs emitted result from the escape to the atmosphere of gaseous fuels and other gaseous substances during production, storage, handling or end-use.

Not all VOCs are emitted from man made sources. In fact, total emissions of VOCs from natural sources, mainly forests, are estimated to be almost six times greater than the anthropogenic source emissions in Canada (XX). In the vast rural areas of Canada, biogenic VOC emissions dominate. However in the more populated and industrialized parts of the country, anthropogenic VOC sources can be several orders of magnitude higher than the more widely distributed, natural VOC emissions.

There are several thousands of VOCs compounds in the natural and polluted troposhere. VOCs can be classified by their "reactivity". The more reactive VOCs have relatively short lives in the atmosphere; they are rapidly converted through photochemical reactions to ozone and other photochemical products such as formaldehyde and hydrogen peroxide. One of the most common methods for measuring VOC reactivity is the use of hydroxyl

radical rate coefficients. Table 1 lists some of the VOC classes and species that are most important in ozone formation, and their hydroxyl radical rate coefficients (Dann 1989). In Table 2, VOC compound classes are ranked in order of decreasing reactivity. Although these rankings are useful indicators of ozone forming potential, reactivity of VOCs in the real world is a complicated function of environmental conditions, in particular ambient VOC and NO_x levels (ARB, 1990). Many of the compounds important in ozone formation derive from anthropogenic sources. However, natural VOC emissions can also play an important role. Of the total natural VOC emissions for Canada it is estimated that 12% of the emissions are isoprene and 50% are mono-terpenes. Terpenes are not included in many atmospheric chemistry schemes because it is believed that the oxidation products of these compounds do not play an important role in ozone formation (Sillman 1987, Finlayson-Pitts 1987, Altshuller 1983). Isoprene, however, can be an important species in rural ozone formation processes.

Long-lived low reactivity VOCs such as chlorinated alkanes and chlorofluorocarbons make no significant contribution to peak ozone episodes. They often remain largely unreacted for many years, with adequate time to reach the upper atmosphere. Chlorofluorocarbons (CFCs) are primary contributors to stratospheric ozone level depletion and are also greenhouse gases. Methane is another long-lived VOC which contributes to the greenhouse effect. Even though it has very low reactivity, methane is also a major contributor, along with NO_x, to the observed long-term buildup of background tropospheric ozone in the Northern hemisphere (Sillman 1987, Altshuller 1986, FRG 1989, Zierock 1988).

Many individual VOCs, are known or suspected of having direct toxic effects on humans ranging from carcinogenesis to neurotoxicity (Dann 1989, Shane 1989). These range from benzene to high volume industrial solvents such as dichloromethane. These are described in more detail in Section II.4 (b).

TABLE 1: IMPORTANT VOLATILE ORGANIC COMPOUND CLASSES AND SPECIES IN AMBIENT AIR RE-OXIDANTS ISSUE (DANN 1989)

Category	Representative Species	Representative Reactivity Coefficient $(10^{3}$ ppm^{-1} min$^{-1})$	Typical Fraction of urban Ambient Air Sample*
1. Alkanes (Paraffins)	Ethane Butane 2,3-Dimethylbutane N-Hexane	0.4 3.8 9.2 8.3	40-70%
2. Alkenes (Olefins)	Ethylene cis-2-Butene Isoprene a-Pinene	12.6 46.5 14.9 78.7	5-12%
3. Aromatics	Benzene m-Xylene Ethylbenzene 1,2,4-Trimethylbenzene	1.9 36.3 11.1 63.3	20-40%
4. Aldehydes & Ketones (Carbonyls)	Formaldehyde Acetaldehyde	13.3 23.7	1-5%

* Excluding Methane

TABLE 2 VOC COMPOUND CLASSES IN ORDER OF DECREASING REACTIVITY (LURMANN CHEMICAL SCHEME)

> C2 alkenes (man-made and natural)
di- and tri-alkyl benzenes
ethylene
mono-alkylbenzenes
formaldehyde
other aldehydes and ketones
>C3 alkanes
C2-C3 alkanes and benzene

II.3 Tropospheric Ozone Concerns

a) Health Effects

Elevated ozone levels have been shown to cause adverse effects on human health and vegetation (Bates 1989, McKee 1988, Friedman 1988, U.S. EPA 1988, Lippmann 1989). Human health effects include immediate, short-term changes in lung function and increased respiratory symptoms. There is ample evidence that some healthy adults who exercise heavily for one to two hours during periods of elevated ozone concentrations (greater than 0.18 ppm) experience pronounced symptoms (such as cough and pain on deep breathing) and significant decreases in lung function. A number of new studies show some temporary reduction of lung function and respiratory system problems among moderately to heavily exercising children and adults exposed for one to two hours to ozone concentrations comparable to peak levels found in many Canadian cities (0.12-0.16 ppm). Short-term decreases in lung function and increased respiratory symptoms have also been shown to occur in healthy, exercising individuals exposed for prolonged periods to ozone as low as 0.12 ppm. A number of researchers have expressed concern about effects occurring at ozone concentrations between 0.08 and 0.12 ppm among people exposed for up to six hours. Epidemiological studies have established correlations of ambient air ozone concentrations with respiratory hospital admissions and "minor restricted activity" (Ozkaynak et al 1988).

Ozone has also been suspected of playing a role in the long-term development of chronic lung diseases. While not dismissing the short-term effects of ozone, many health professionals appear to be more concerned that repeated exposure to ozone over a lifetime may result in permanent impairment of the lung. New epidemiologic research suggests that accelerated rates of

decline of lung function with aging occur among residents of communities with high ozone concentrations. Clinical studies of humans have recently shown that prolonged exposure to low ozone concentrations results in progressively larger changes in respiratory function and symptoms with time. Animal studies have shown that prolonged ozone exposure can cause biochemical and structural injury to the lung. Some of these changes are suspected of playing a role in the development of chronic lung disease, although inherent uncertainties in extrapolating from animal data make it difficult to assess human risk from these studies. Together, these studies suggest that there may be some persistent effects associated with long-term exposure to ozone. However, at this time our understanding of the contribution of ozone to the development of chronic lung disease is limited (Friedman et al 1988).

Two groups have been identified by the U.S. Environmental Protection Agency (EPA) as being potentially at increased risk of developing adverse health effects when exposed to elevated ozone concentrations: 1) a subgroup of the general population with preexisting respiratory diesease (e.g. asthma, chronic obstructive pulmonary disease), and 2) those individuals who exercise or work outdoors. The first group is of concern because their respiratory systems are already compromised. The strongest evidence of increased risk exists for people who exercise heavily outdoors. They are at risk because the doses they receive are high due to their increased breathing rate. EPA also estimates that about 5 to 20 percent of the healthy population may represent a subgroup of "responders" who may be significantly more responsive than the general population to the same dose of ozone (Friedman et al 1988).

b) Vegetation Effects

The effects of ozone on vegetation have been well documented. Vegetation damage is usually in the form of foliar injury which reduces productivity. It is estimated that at many locations throughout the southern and eastern halves of the United States, rural ozone concentrations are high enough to reduce yields of economically important crops by 1 to 20 percent compared to yields that would be expected if ozone concentrations were at natural background levels. The most heavily affected crops include soybeans,

wheat, cotton, and some types of produce. Agricultural benefits of about $2 billion would be anticipated in the U.S. if rural ozone concentrations could be reduced by 25 percent. Most of the Canadian research has focused on ozone injury to crops in southern Ontario where seasonal mean ozone levels of 40-50 ppb occur. Ozone sensitive crops in this area include beans, tomatoes, tobacco, potatoes, corn, soyabeans and wheat. It is estimated that the combined losses in crop production and revenues to ornamental plant growers in southern Ontario from ozone concentrations of 40-50 ppb is $17 to $70 million per year, depending on the seasonal precursor emissions and the regional weather patterns (Pearson and Donnan 1989).

Ozone causes foliar injury and reduced growth rates in sensitive trees of several species. Exposure to ozone can lead to increased susceptibility to diseases and other stresses, increased mortality of individual trees, and eventually to overall decline of affected species. All of these effects of exposure to ozone have been observed in forests in the mountains bordering the Los Angeles basin. Ozone damage has also heen observed in ponderosa and Jeffrey pine at other locations in California. In the eastern United States, ozone is held to be responsible for widespread foliar injury, reduced growth, and increased mortality in eastern white pine. Ozone has also been suggested as a causal or contributing agent in reported declines or growth rate reductions of red spruce, yellow pine and sugar maple (Friedman etal 1988).

Although many forest species in Ontario, Quebec and the Maritimes have been shown to be in a state of decline, the state of knowledge at this time is insufficient to develop reliable estimates of the contribution of air pollutants including ozone to this decline (Jensen 1984, Norby 1984).

c) Ambient Air Concentrations

There are three areas of concern with elevated ground-level ozone concentrations:

1) the general increase in "background" levels both in Canada and globally

2) the increase in growing season ozone levels

3) short duration ozone episodes (hours to days) during which acceptable health and environmental concentrations are exceeded.

Background O_3 is associated with stratospheric O_3 intrusion into the troposhere, natural VOC (including methane) and NO_x emissions, and anthropogenic NO_x and VOC (including methane) emissions. In some regional settings, background levels are now in the 30-50 ppb range, elevated from estimated natural levels of 10-30 ppb. Ozone generated in summer from anthropogenic NO_x and VOC emissions is added to the elevated background levels, increasing the magnitude of summertime mean concentrations, the magnitude of peak concentrations during O_3 episodes, and the number of hours per year that O_3 levels exceed the maximum acceptable concentrations defined in Canadian air quality objectives (Appendix B).

In Canada, ozone episodes occur almost exclusively during summer months and primarily on hot sunny days. In eastern Canada, stagnation conditions associated with stable high pressure systems lead to the highest ozone concentrations. Transport of ozone and precursors from the United States can be an important feature in some episodes. Ozone episodes are generally of relatively short duration (1-5 days). Peak O_3 concentrations during typical episodes in parts of Canada are often more than twice the maximum acceptable level of 82 ppb. The location of ozone problem areas and hours avove 82 ppb (1982-86) are illustrated in Figure 2. Because the highest levels normally occur in the more highly populated regions of the country, it is estimated that more than half of the Canadian population is exposed during the summer months to O_3 levels which are known to have health effects.

Over the past five years, Victoria is the only major urban area (populations greater than 50,000 where routine monitoring takes place) in Canada that has not recorded readings in excess of the maximum acceptable level. The urban areas in the B.C. Lower Mainland and the Windsor-Quebec City corridor and Saint John, New Brunswick are the areas where ozone levels most frequently exceed environmental quality requirements.

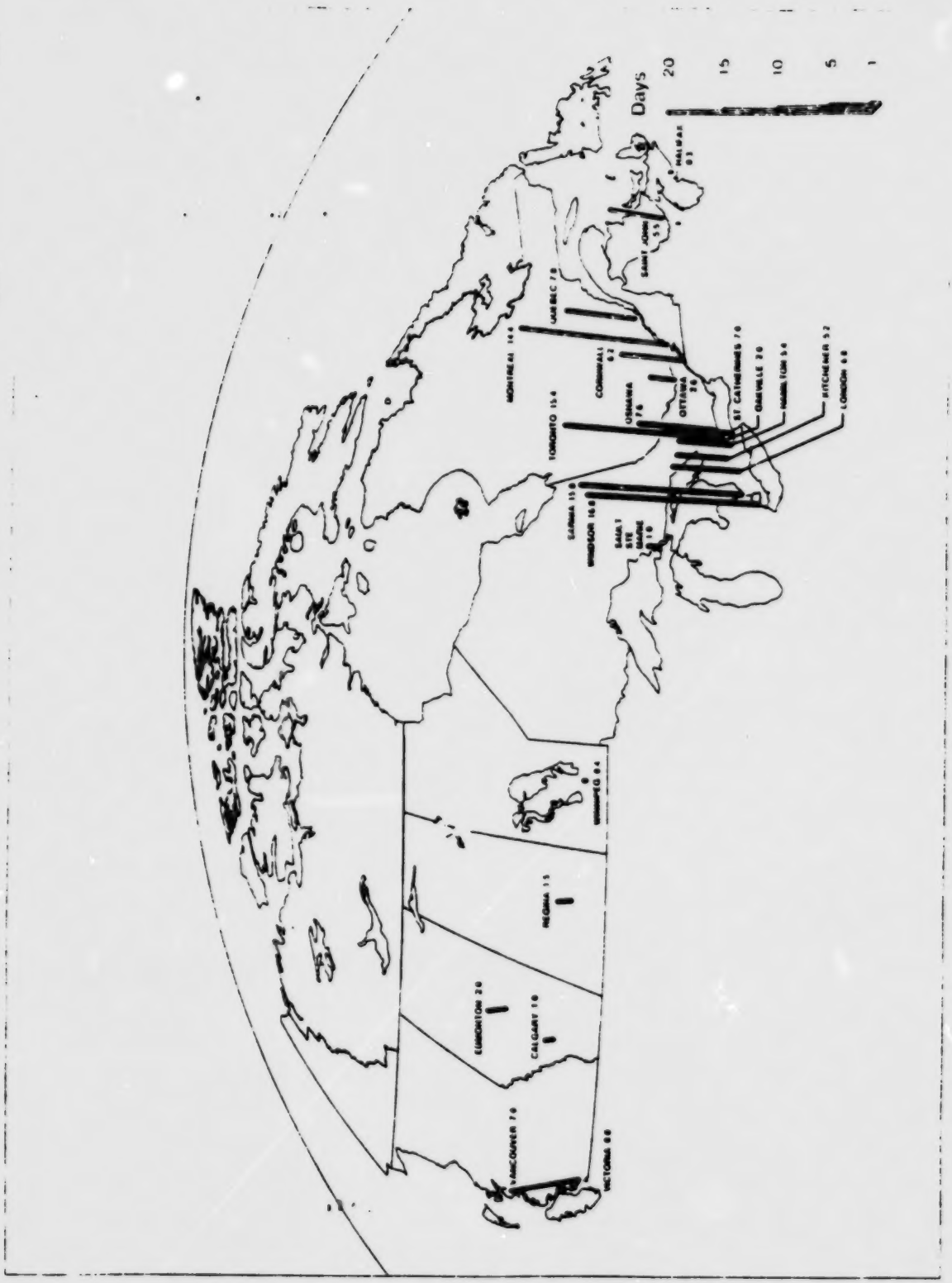


FIGURE 2 AVERAGE NUMBER OF DAYS PER YEAR EXCEEDING THE ONE HOUR OZONE AIR QUALITY OBJECTIVE (82ppb), 1982-1986

Appendix D contains a listing of maximum ozone concentrations and hours per year above the Canadian maximum acceptable concentration of 82 ppb for most monitoring sites in the country for the period 1983-1989. The range of ozone maximum concentrations and hours >82 ppb (both based on average of three highest years) for monitoring sites in each of four geographic regions are illustrated in Figures 3 and 4.

The plots in Figures 3 and 4 indicate that the median O_3 value is above the 82 ppb maximum acceptable level for all regions, including the North-Prairies region. In all regions but the North-Prairies region, peak ozone concentrations were above 82 ppb at all monitoring sites in all three years. Hours per year with ozone concentrations above 82 ppb are much higher in the Windsor-Quebec corridor than in any other region.

d) Regional Air Quality

Because the concerns with tropospheric ozone vary in different parts of the country it is useful to examine several regional settings in more detail. The ozone situation in each of four geographic regions is described below.

Lower Fraser Valley

The lower Fraser Valley (LFV) region is considered to encompass the Greater Vancouver Regional District (GVRD) and the areas to the east as far as Chilliwack.

This is a unique geographic setting where mountains immediately inland cause air masses moving inland off the ocean to rise and be channelled between mountain ranges. As illustrated in Figure 5, ozone tends to concentrate at the head of Burrard Inlet, but also to be transported a considerable distance between the mountain formations up the Fraser Valley. Peak concentrations around the head of Burrard Inlet are typically in the 150 ppb range. When episodes occur, levels in the 110-130 ppb range can persist 50-100 km downwind up the Fraser Valley, well beyond the primary NO_x and VOC source area. Within the GVRD itself, the meteorology is quite complicated with onshore-offshore movement and micro-scale influences on ozone concentrations (Davis 1984, Concord 1989).

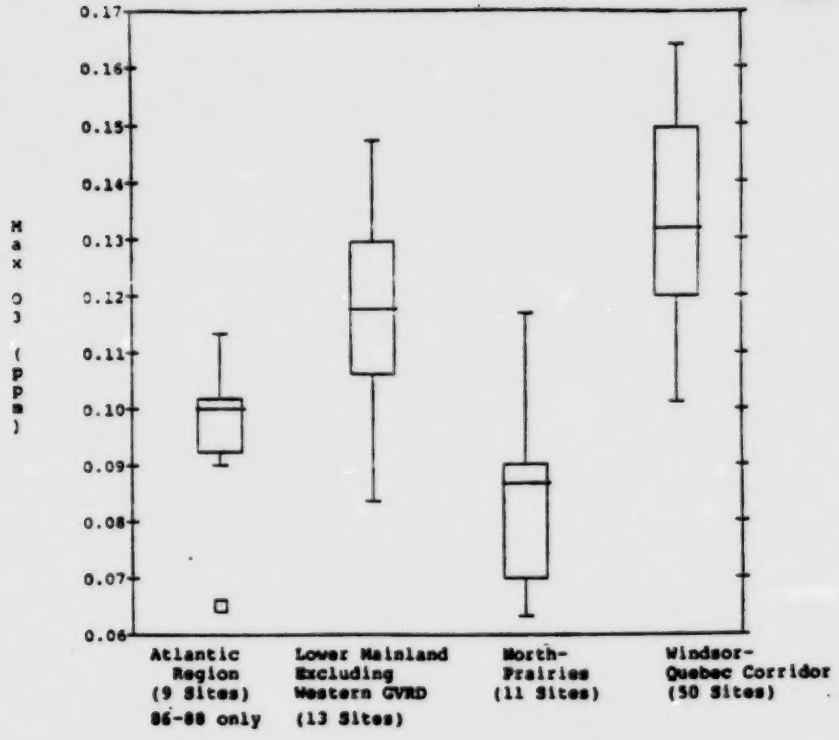


FIGURE 3 AVERAGE MAX. OZONE FOR THREE HIGHEST YEARS 83-89

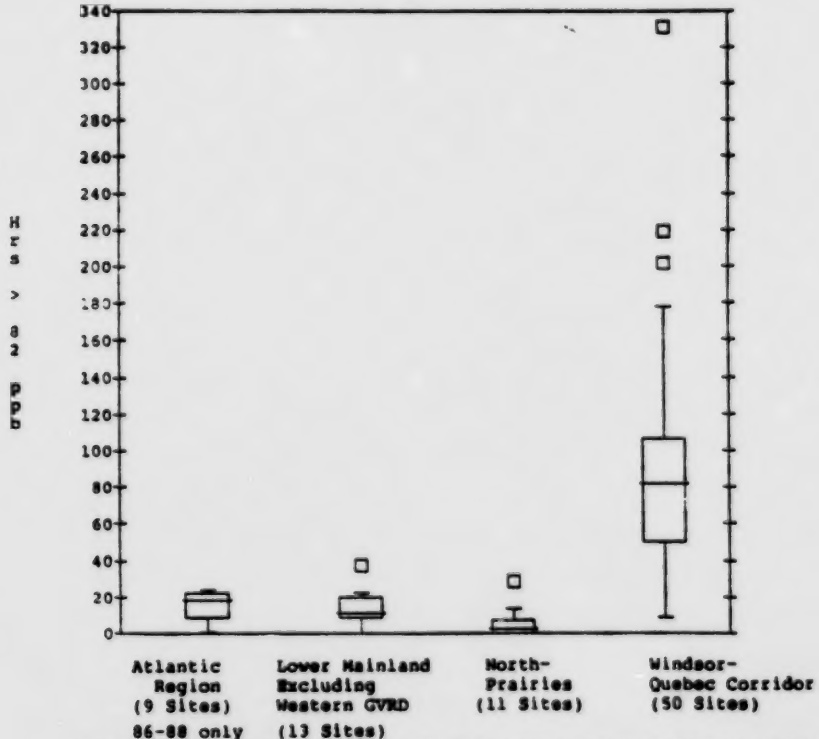


FIGURE 4 AVERAGE HRS > 82 PPB FOR THREE HIGHEST YEARS 83-89

(Average of 3 Highest Years 1983 - 1989)

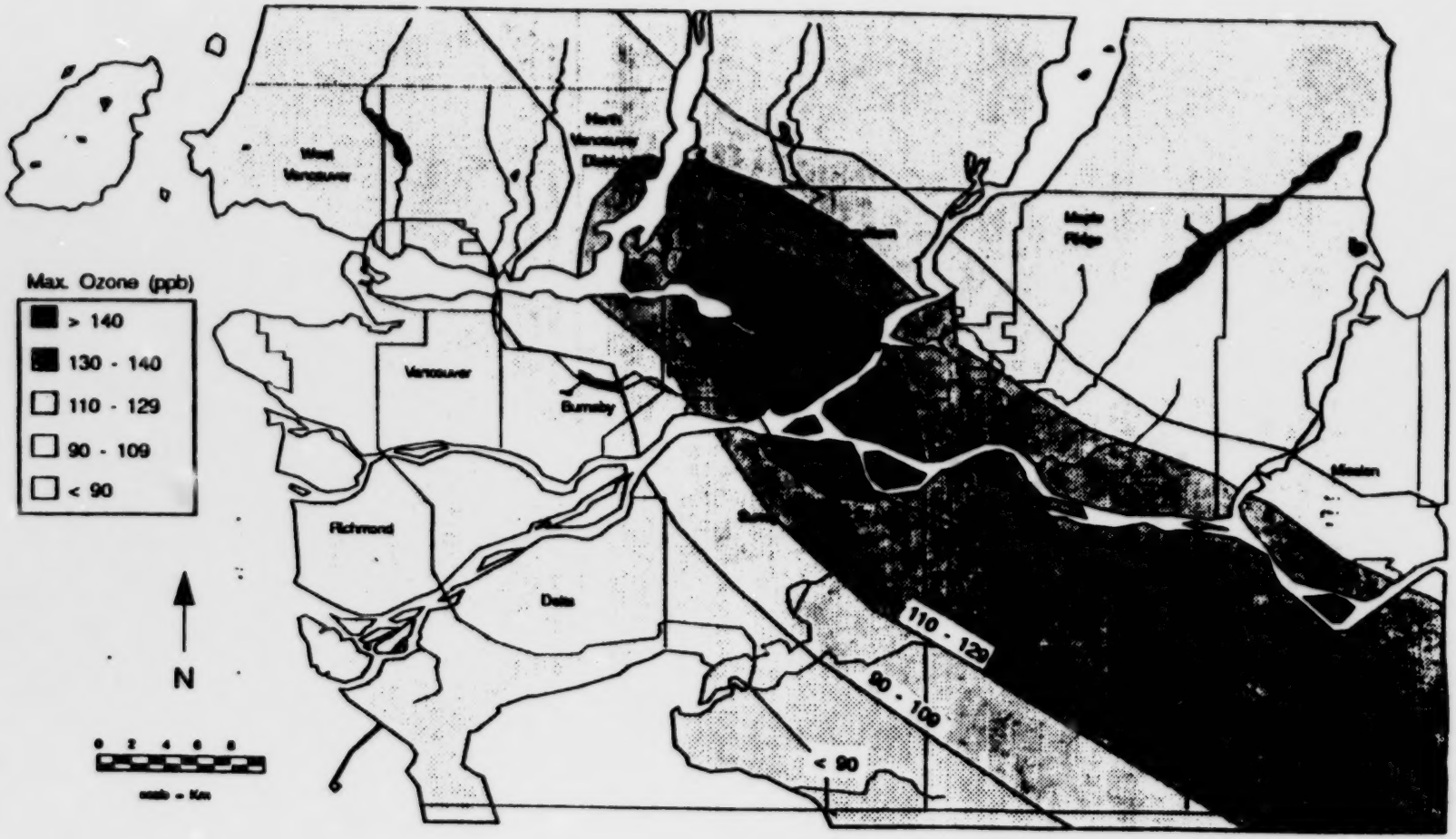


FIGURE 5 MAXIMUM CONCENTRATIONS IN THE LOWER FRASER VALLEY (LFV) REGION

The elevated O_3 levels in the LFV are caused primarily by locally generated NO_x and VOC precursor pollutants, although some episodes can be created by ozone and precursors being transported northward from the Puget Sound area of the State of Washington (NO_x/VOC Work Group on modelling).

The Southern Prairies

This region encompasses the lower half of the three prairie provinces where the vast majority of the prairie population resides and the majority of the NO_x and VOC sources in these provinces exist.

Tropospheric ozone throughout this region is not a serious problem. In the foothills area of Alberta and in near-field downwind areas, relatively high background O_3 levels are characteristic (Angle and Sandhu 1985, Legge 1988). This may be partly due to the elevation and latitude of the monitoring sites used to collect rural data or possibly, due to anthropogenic NO_x emissions in combination with biogenic VOC emissions. The ambient air NO_x concentrations shown in Figure 6 would be sufficient to generate ozone over large areas of Alberta in the presence of sufficient VOCs.

Alberta has relatively high total NO_x emissions but the sources are quite widely dispersed with a lower percentage of emissions in the large urban areas than in any other province. There have been a few short-duration excursions marginally above the maximum acceptable O_3 level of 82 ppb recorded in the urban centres of Alberta. There has been little long term ozone data collected outside the urban centres but it is thought that emissions are not high enough to cause prolonged high ozone episodes.

Ozone maxima are even lower and less frequent in the large urban centres of Saskatchewan and Manitoba. Total NO_x and VOC emissions in these two provinces are much lower than in Alberta. However, unlike Alberta, a very high proportion of total provincial NO_x and VOC emissions are concentrated in the urban centres.

In all three prairie provinces the influence of imported pollutants from U.S. sources on urban ozone episodes is expected to be minimal.

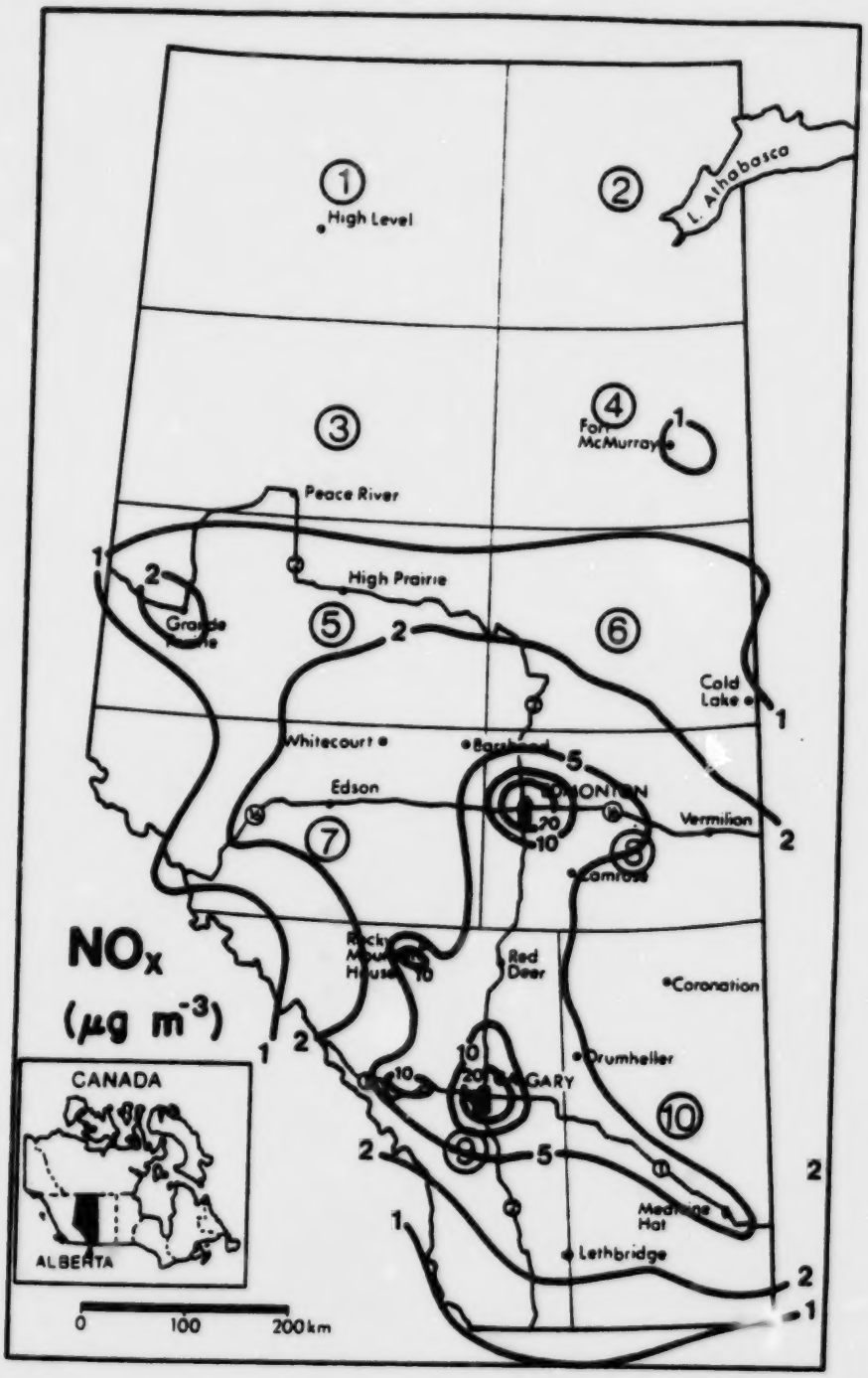


FIGURE 6 AVERAGE ANNUAL NO_x CONCENTRATIONS (ug/m^3) IN ALBERTA (LEGGE 1998)

Windsor - Quebec Corridor

For the purposes of this plan, the Windsor-Quebec Corridor (WQC) is considered to be a relatively narrow band along the north shores of Lake Erie, Lake Ontario and the St. Lawrence River in Ontario, and straddling the St. Lawrence River from the Ontario border to Quebec City in Quebec.

It is within the WQC that the highest frequency and longest duration of ozone excursions above the maximum acceptable level occur. Maximum summer O_3 levels in southern Ontario and southern Quebec are shown in Figure 7. In the region from Windsor to immediately downwind of Toronto, peak ozone levels are typically in the 110-160 ppb range, with maximum recorded values of about 190 ppb. The greatest number of hours in excess of the 82 ppb maximum acceptable standard have occured in the vicinity of Long Point in Lake Erie and along the eastern shore of Lake Huron in the Kincardin area. (See Appendix D)

As you proceed northeasterly from Toronto up the corridor there is a slight dip in ozone peak levels between Toronto and Montreal, with summer peaks typically in the 90-130 ppb range. They increase again in and immediately downwind of Montreal to levels typically in the 100-160 ppb range, with a maximum recorded hourly value of 180 ppb. From Montreal toward Quebec City peak levels tend to decrease gradually. Although hourly values as high as 160 ppb have been recorded in Quebec city, peak O_3 levels are typically in the 70-110 ppb range.

Also of interest are the growing season O_3 concentrations in the WQC area, where much of the agricultural activity in Ontario and Quebec takes place. Figure 8 shows average growing season O_3 concentrations in southern Ontario and southern Quebec for the 1983-1989 period. Mean summer O_3 concentrations greater than 50 ppb occur in the Long Point region along the north shore of Lake Erie. All parts of Ontario south of Toronto have growing season mean concentrations in excess of 40 ppb. Similar levels prevail over a wide band along the St. Lawrence River between the Ontario border and Quebec City. Growing season mean levels are greater than 32 ppb at all locations throughout the corridor.

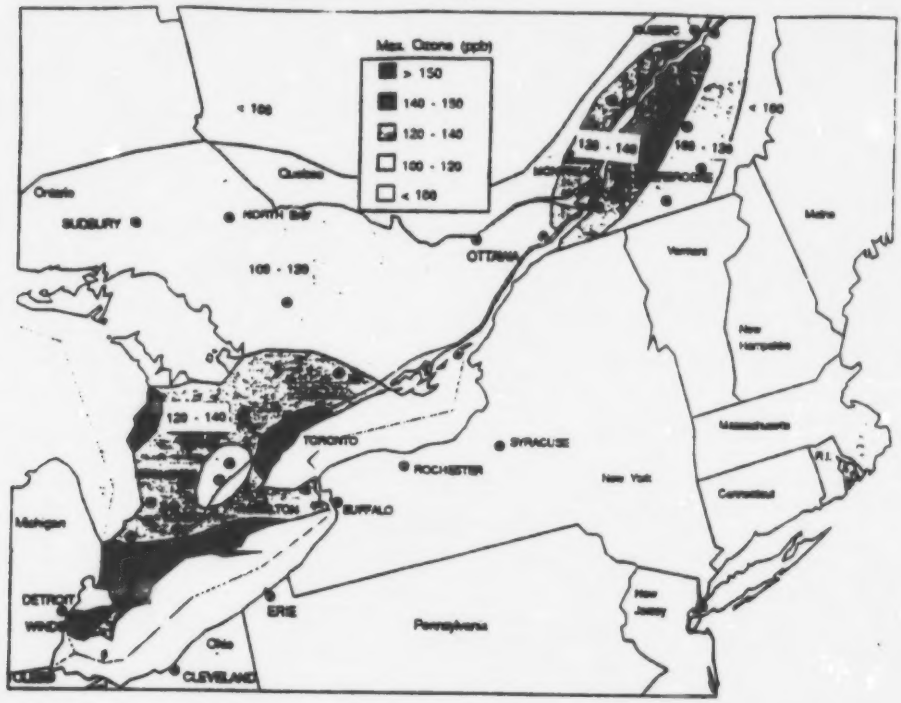


FIGURE 7 MAXIMUM OZONE CONCENTRATIONS - WINDSOR - QUEBEC CORRIDOR (WQC)

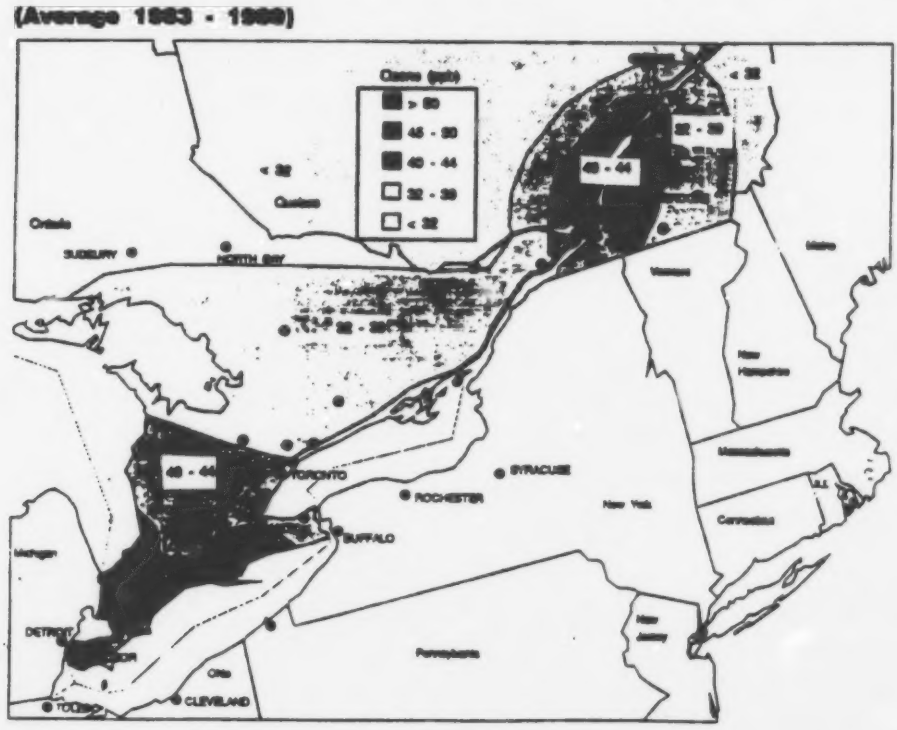


FIGURE 8 GROWING SEASON O_3 CONCENTRATIONS - WINDSOR - QUEBEC CORRIDOR (WQC)

While there are very significant sources of NO_x and VOCs within the WQC, imported O_3, NO_x and VOCs from the United States are expected to have a major influence on both the peak and growing season O_3 levels.

Ozone episodes in the WQC generally occur under prevailing south westerly winds along the backside of anti-cyclones (high-pressure areas) as illustrated in Figure 9. The northeasterly flowing air mass picks up pollutants from major U.S. sources along the southern shores of the Great Lakes and farther upwind and carries them up the corridor. The cities of Detroit (population 4.5 million)and Cleveland (population 2 million), both large sources of NO_x and VOCs, sit essentially at the head of the corridor. Under southwesterly winds, high ozone concentrations in the upper parts of the corridor will be due almost entirely to imported pollution. The fact that the Long Point area has the greatest number of hours above the maximum acceptable O_3 level supports this conclusion. As you move down the corridor to Toronto and beyond the influence of U.S. sources diminishes gradually as the distance downwind from these sources increases and major Canadian emission sources are encountered. (See further analysis in Section V)

Southern Atlantic Region

This region covers the land areas around the Bay of Fundy including southern New Brunswick and all of Nova Scotia west of Halifax.

Maximum O_3 levels in the Southern Atlantic Region occur in the Saint John area of New Brunswick where peak hourly levels of 80-100 ppb have been recorded (see Appendix D, 86-88 data only). Levels in the same range have been recorded on the south side of the Bay of Fundy in Nova Scotia. Farther eastward in Halifax peak O_3 levels are generally considerably lower in the 70-100 ppb range.

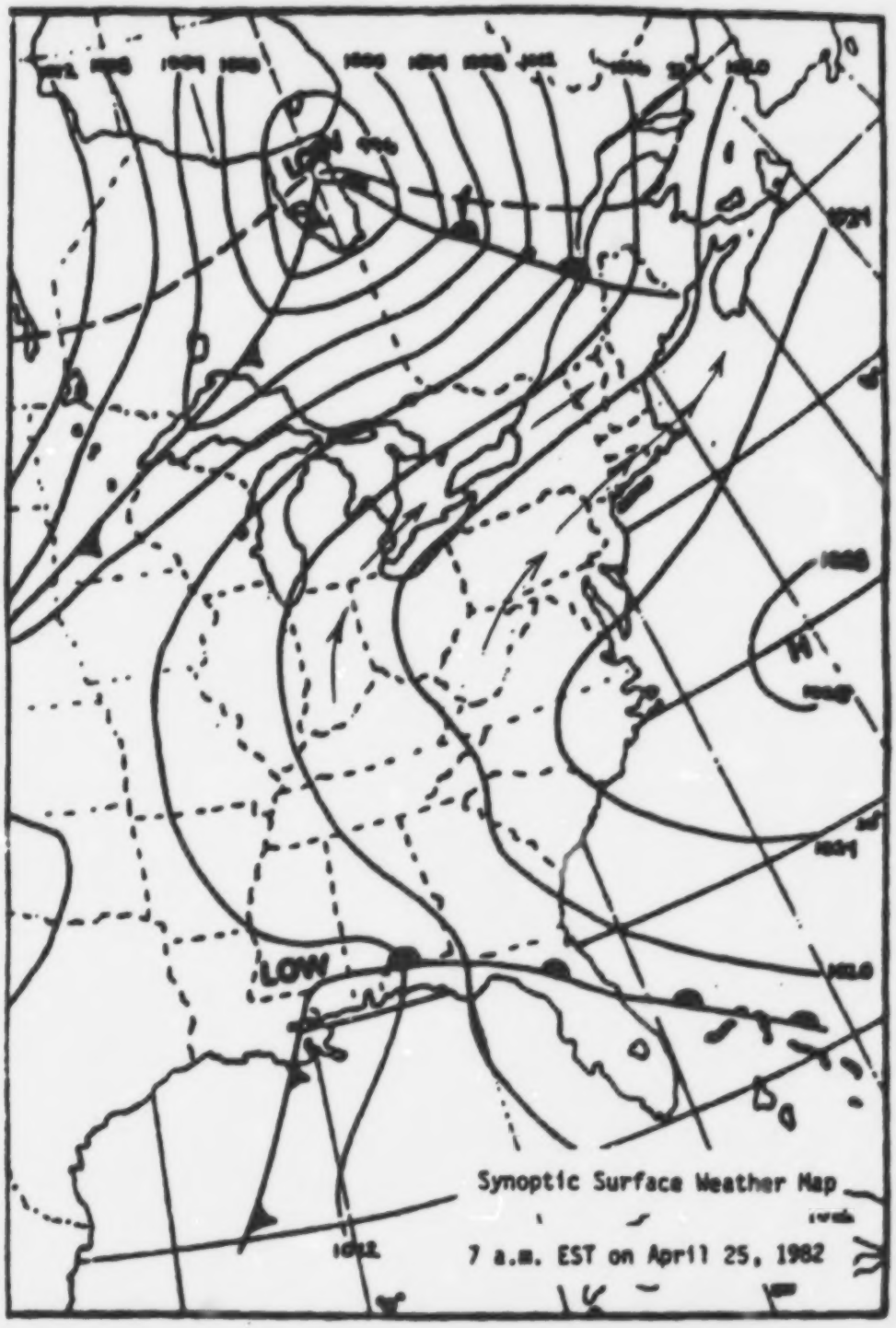


FIGURE 9 TYPICAL WEATHER PATTERN DURING OZONE EPISODES IN THE WINDSOR - QUEBEC CORRIDOR (WQC)

Ozone episodes in the Southern Atlantic Region can be attributed largely to imported pollutants from the eastern seaboard of the United States. This is supported by the fact that peak ozone levels often occur in the middle of the night while typically ozone peaks from locally generated NO_x and VOCs would be expected to occur in late afternoon. Weather patterns during episodes in the Southern Atlantic Region are similar to those during episodes in the WQC.

II.4 Other Environmental Concerns with NO_x and VOC Emissions

a) Nitrogen Compounds

Nitrogen Dioxide

Above certain concentrations in the atmosphere, nitrogen dioxide (NO_2) can cause human health effects such as respiratory problems. Canadian ambient air quality objectives are in place defining the maximum desirable, maximum acceptable and maximum tolerable levels of NO_2 in the atmosphere (see Appendix D). Nitrogen dioxide ambient air concentrations have been generally decreasing in recent years due to declining NO_x emissions from automobiles, and are now generally below the maximum acceptable level in Canadian Cities. Although there were some exceedances in 1987 and earlier years, no sites in the country exceeded air quality objectives for NO_2 in 1988. Annual average NO_2 levels in urban centres in 1988 were typically in the range of 15 to 35 ppb (the maximum acceptable level is 53 ppb).

Nitrate and Nitric Acid

The long term acidification of surface waters in Eastern Canada is primarily associated with emissions of sulphur dioxide (SO_2). However, nitrate deposition may be aggravating acidification in some areas. No critical load has been established yet for nitrate deposition in Canada. Based on international work in this area, a value somewhere in the range of 5-15 kg/ha (as total nitrogen) may be selected eventually. Maximum total wet

nitrogen deposition in Canada is currently about 10 kg/ha. Assuming that dry nitrogen deposition contributes 30-60% of total nitrogen deposition (CCME 1989), total nitrogen deposition in some areas could already be in the 15-25 kg/ha range, or above the upper boundary of the range being considered for a nitrate critical load.

Nitrogen compounds are known to be a significant contributor to spring "acid shock" in some areas of eastern Canada. Also, any contribution of nitric acid to increased acidity of the precipitation itself will accentuate direct effects, such as structural damage to buildings.

It has been suggested that beneficial effects of nitrogen deposition due to an increased nutrient supply to vegetation can be expected with moderate rates of nitrate deposition. However, in parts of Canada where nitrate deposition is highest, NO_x control actions to decrease total nitrate deposition appear to be justified.

Nitrous Oxide

Approximately one-third of total global nitrous oxide (N_2O) emissions are anthropogenic, resulting mainly from fertilizer application and to a lesser extent from large stationary combustion sources. Mobile sources are not significant emitters of N_2O.

Nitrous oxide (N_2O) is a small contributor (5%) to global atmospheric warming and also has the potential to contribute to stratospheric ozone depletion. However, in the present situation of elevated levels of chlorine compounds in the stratosphere (mainly due to chlorofluorocarbons), a situation that will prevail for decades, ozone depletion is slowed by increasing N_2O concentrations due to interference of the N_2O with the chlorine-catalyzed destruction of ozone.

b) Volatile Organic Compounds

Direct Toxic Effects

Many individual VOCs are known or suspected of having direct toxic effects on humans ranging from carcinogenesis to neurotoxicity (Dann 1989, Shane 1989). About half of the 44 substances on the current Priority Substances List (PSL) of the Canadian Environmental Act are VOCs, ranging from benzene, a component of gasoline, to high volume industrial solvents (see Table 3). All substances on the PSL are undergoing assesment to determine whether they should be declared toxic under the Act. Regulations will be prepared for those that are declared toxic. The report of the NO_x/VOC Work Group on Effects contains an analysis of the health effects of several selected VOCs.

As long as a reduction in one type of VOC does not result in increases in other equally or more toxic VOCs, reduction in VOC emissions generally for the purpose of reducing tropospheric ozone levels, will have the additional benefits of reducing human exposure to toxic air pollutants.

Stratospheric Ozone Layer Depletion

Chloroflorocarbons (CFCs), which are the primary contributor to stratospheric ozone level depletion, are VOCs. They are, however, long-lived, low reactivity VOCs and make no significant contribution to the formation of tropospheric ozone. The concern might be with CFC substitutes, probably HCFCs, that have higher reactivity and greater tropospheric ozone-forming potential than the CFCs currently being used. No estimate has been made of the significance of this to ozone formation in the future.

Global Warming

The VOCs involved significantly in global warming are CFCs and methane, estimated to contribute 13% and 18% respectively to the greenhouse effect. Any benefits or disbenefits the plan might have regarding methane emissions should be identified.

TABLE 3 VOLATILE ORGANIC COMPOUNDS ON THE CEPA PRIORITY SUBSTANCES LIST (DANN 1989)

GROUP 1:	(Assessment within 3 Years)
	Benzene
	Methyl Tertiary-butyl ether
GROUP 2:	(Assessment within 4 Years)
	Chlorobenzene
	1,2-Dicholorobenzene
	1,4-Dichlorobenzene
	1,2-Dichloroethane
	Dichloromethane
	Styrene
	1,1,2,2-Tetrachlorethylene
	Tetrachloroethylene
	Toluene
	Trichlorobenzene
	1,1,1-Trichloroethane
	Trichloroethylene
	Xylenes
GROUP 3:	(Assessment within 5 Years)
	bis (2-Chloroethyl) ether *
	bis (Chloromethyl) ether*

* - not currently measured

III PRE-PLAN NO_x AND VOC EMISSIONS

III.1 Emission Forecasts and Assumptions

Current (1985) and projected (to 2005) emissions of NO_x and VOCs are provided both nationally and provincially in Appendix A. This emission forecast, referred to as NO_x/VOC Emission Forecast 90-A, is the emission data set upon which the plan is based.

Summary information from Emission Forecast 90-A is presented in Tables 4 and 5 and Figures 10-13. Tables 4 and 5 list the 1985 and 2005 national emission values and the percentage change between these years. Figured 10 and 11 show the general source categories and projected NO_x and VOC emissions in each category nationally for the period 1985 to 2005. Figures 12 and 13 show the distribution of NO_x and VOC emissions among provinces for each of 3 selected years - 1985, 1995 and 2005.

Assumptions and information sources used in developing Forecast 90-A are described in Appendix A and in the report of the Work Group on NO_x/VOC Emission Inventories. Some of the key information sources used are:

- National Energy Board (NEB) estimates of car and truck stock growth rates (NEB 1998).
- NEB estimates of energy demand for all energy related sectors by fuel type and by province/territory (NEB 1988).
- Informetrica economic and population growth estimates for other sectors (by sector and by province/territory).
- Electricity demand growth rates and fuel mixes provided by provincial power utilities.
- Provincial base year (1985) emission data.

TABLE 4 NO_x EMISSIONS IN 1985 AND 2005 AND PERCENTAGE CHANGE

Source	NO_x EMISSIONS (kt) 1985	2005	% Change
Mobile			
On-Road Vehicles	739.3	500.0	-32
Off-Road Vehicles	260.5	346.2	+33
Railroads	132.1	113.0	-14
Aircraft	33.4	42.3	+27
Marine	14.9	18.5	+24
Total Mobile	1180.2	1020.0	-14
Stationary			
Power Generation	247.9	351.7	+42
Natural Gas	158.8	112.5	-29
Other Ind. Fuel Comb.	119.4	178.9	+50
Commercial Fuel Comb.	25.8	28.4	+10
Residential Fuel Comb.	41.5	36.9	-11
Industrial Processes	89.0	139.7	+57
Incineration/Misc.	24.3	34.6	+42
Total Stationary	706.7	882.7	+25
Total	1886.9	1902.7	+ 1

TABLE 5 VOC EMISSIONS IN 1985 AND 2005 AND PERCENTAGE CHANGE

Source	VOC Emissions (kt) 1985	2005	% Change
Mobile			
On-Road Vehicles	613.6	401.7	-35
Off-Road Vehicles	90.7	108.6	+20
Marine	27.9	31.5	+13
Aircraft	10.1	13.2	+31
Railroads	7.0	6.0	-14
Total Mobile	749.3	561.0	-25
Stationary			
Solvent Use	502.0	602.9	+20
Industrial Processes	223.4	394.9	+77
Fuelwood Combustion	107.7	132.7	+23
Slash Burning	80.6	129.0	+60
Gasoline Distribution	109.0	124.4	+14
Ind. Fuel Combustion	49.5	63.9	+29
Other	32.0	38.6	+21
Total Stationary	1104.2	1486.4	+35
Total	1853.5	2047.4	+10

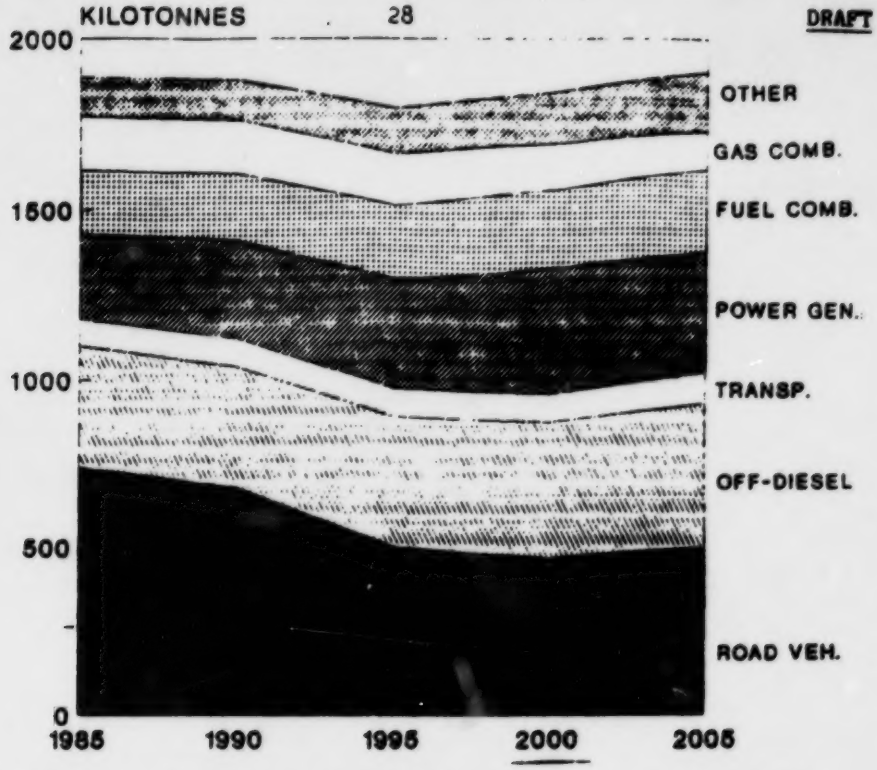


FIGURE 10 NATIONAL NO_x EMISSIONS PROJECTIONS - 1985 TO 2005

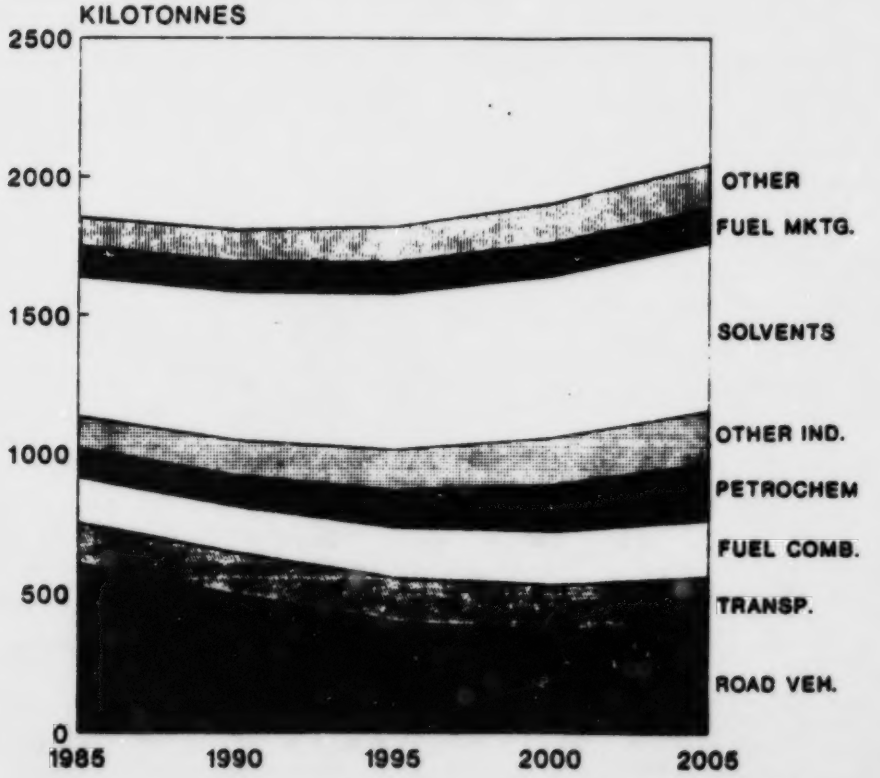


FIGURE 11 NATIONAL VOC EMISSIONS PROJECTIONS - 1985 - 2005

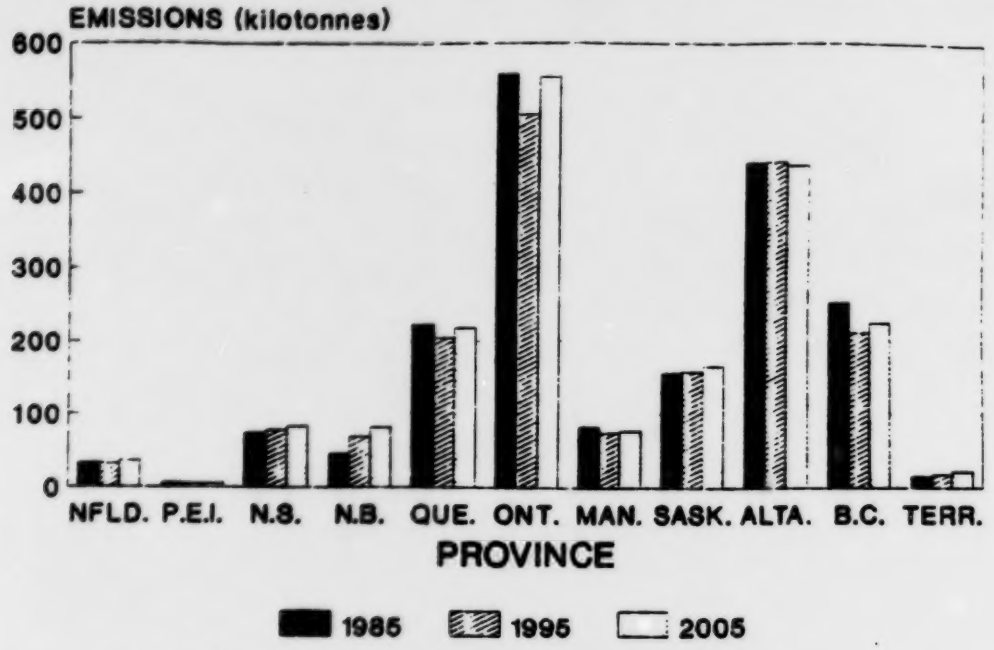


FIGURE 12 PROVINCIAL DISTRIBUTION OF NO_x EMISSIONS

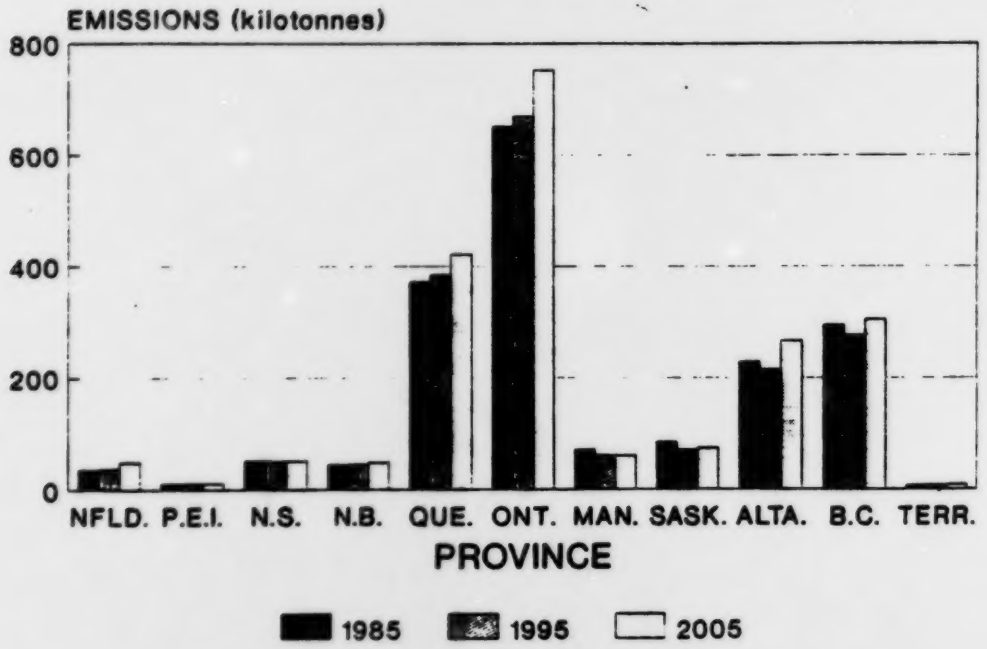


FIGURE 13 PROVINCIAL DISTRIBUTION OF VOC EMISSIONS

Emission Forecast 90-A is based on the current level of control for all source categories. For example, the motor vehicle emission projections take into account the effect of the existing (1987) tailpipe standards (1.0 g/mi for NO_x, 0.41 g/mi for hydrocarbons) over the 1985 to 2005 time period. They do not account for any of the measures announced by CCME in October, 1989 for future application of tighter tailpipe standards, fuel volatility reduction, or inspection and maintenance programs. Similarly emissions from gasoline marketing and distribution assume the status quo, and do not account for the effect of implementing Stage 1 vapour recovery as announced by CCME in October, 1990.

Factors other than emission controls can change emission rates over time. Adjustments have been made for the following:

- The penetration into Canada of heavy duty vehicle engines designed to meet the tighter U.S. NO_x standard of 5 g/BHP-hr after 1991 (without any change in the Canadian standard of 6 g/BHP hr).

- The effect of Ontario Hydro's demand side management (DSM) program (accounted for in Ontario electricity demand forecasts). No other utility DSM programs have been accounted for.

- Changes in rail transport systems including replacement of diesel locomotives (at the rate of 40 per year starting in 1995), operational improvements and reduced passenger service.

Motor vehicle emissions have been calculated using a Canadianized version of the recently acquired MOBILE 4C model developed by the U.S. Environmental Protection Agency (NO_x/VOC Workgroup on Emission Inventories). MOBILE 4C computes both tailpipe and running loss emissions from motor vehicles and accounts for factors such as tampering rates, fuel volatility and ambient temperatures.

For some sectors, the lack of information on the extent of controls currently being applied required that "no control" emission factors be used. Examples are VOC controls in the petrochemical industry and in many of the solvent use industry categories.

It should be recognized that any emission forecast involves many assumptions regarding such things as economic growth, emission regulations, rate of penetration of emission controls, mixes of energy generation types, influence of energy conservation and product substitution initiatives and other factors. Emission Forecast 90-A represents the best current estimate of present and future emissions. It is a snapshot in time with full recognition that it will need to be updated regularly during the life of the plan. Future editions of the plan will no doubt relate to the most recent forecast available at the time those editions are prepared.

III.2 Observations on Emission Trends and Sectoral Contributions

Several general observations from the Forecast 90-A emission projections for NO_x and VOCs are made below.

a) **Nitrogen Oxide Emissions**

1. NO_x emissions nationally are projected to decline over the next 5 years, reaching a level in 1995 about 5% below the 1985 level. After 1995, overall emissions begin an upward trend which presists to 2005 and beyond.

2. The reduction in emissions in the near-term is due to a sharp decline in both light duty and heavy duty vehicle emissions between 1990 and 1995, combined with modest reductions in emissions from natural gas plants and rail transport. The combined reductions more than offset emission increases in other source categories.

3. By 1995, the effectiveness of the current motor vehicle emission standards in reducing emissions will for the most part have been realized by the penetration of new vehicles into the motor vehicle population. Motor vehicle emissions level off beyond 1995 as the growing vehicle population offsets further reductions resulting from the current standards.

4. With the leveling-off of motor vehicle emissions after 1995, the increasing emissions in other sectors due to continuing growth in population and industrial activity cause NO_x emissions nationally to begin a slow but sustained increase to 2005 and beyond.

5. The sectors with the largest projected increases in NO_x emissions are industrial boilers and heaters (50%), industrial processes (57%) and power generation (42%). Although total mobile source emissions decrease, emissions from offroad (mainly diesel) vehicles, a major source category, increase by 33%.

4. Geographically, most provinces parallel the national trend with a freeze in NO_x emissions to 2005. B.C. will undergo an 11% decrease and increases will occur in Newfoundland, Nova Scotia, New Brunswick and Saskatchewan.

b) Volatile Organic Compounds (VOCs)

1) VOC emissions nationally in year 2005 will be 10% above the current (1985) level. A level 6% below the 1985 level is projected for the early 1990s followed by a gradual and sustained increase to 2005.

2) As with NO_x emissions, the rapid decline in VOC emissions from motor vehicles in the near-term offsets gradually increasing emissions in most other sectors. However, motor vehicles contribute a smaller percentage to total VOC emissions than they do to total NO_x emissions. Because of this, the decline in emissions is more quickly overtaken by the presistent stationary source increases. VOC emissions nationally appear to have already bottomed out (in 1990) and without further control an accelerating rate of increase is anticipated to 2005 and beyond.

3) Sectors contributing most to this increase are organic chemical plants (92% increase), other industrial processes (74% increase) and solvent use (20% increase).

4) By 2005, solvent use is projected to be the largest single VOC source category, contributing 30% of all VOC emissions, compared to 16% from light duty vehicles and 10% from organic chemical plants, the next largest source categories. VOC emissions from solvents in 2005 will, in fact, be greater than VOC emissions from all mobile sources combined.

5) Solvent use can be divided into numerous subcategories, the largest being paints and coatings. Others include glues and adhesives, printing, dry cleaning, auto care and maintenance products, household and personal care products, and numerous other solvent uses. A breakdown of VOC emissions in the various subcategories is provided in the report of The NO_x/VOC Work Group an Control Technologies, Sub-Group 6.4.

IV PRINCIPLES AND APPROACH

IV.1 PRINCIPLES FOR ALLOCATING EMISSION REDUCTIONS

Through the multistakeholder consultation process undertaken as part of the plan development program, a set of principles for allocating NO_x and VOC reductions were developed for use as a guide in preparing the plan.

These principles are contained in Annexe XX, but are repeated here because they provide fundamental guidance on the scope and content of the plan, reached through a multistakeholder census process. They are "verbatum" as follows:

1. Solutions to Real Problems

The management plan should be aimed at solving or preventing real environmental and human health problems, rather than responding to arbitrary criteria.

In particular it should deal with the following environmental protection priorities by targeting compliance in Canada with relevant National or Provincial Air Quality Criteria.

The Environmental Protection Priorities are:

1) Human Health
2) Urban Air Quality
3) Rural Air Quality
4) Meeting International Environmental Protection Obligations
   e.g. NO_x freeze domestically
   e.g. NO_x freeze for Transborder Flows

2. Effectiveness

The management plan should allocate reductions based on their environmental and economic effectiveness. Ideally an allocation based on effectiveness would allocate reductions to those sources with the lowest cost of reduction per unit of improvement in air quality.

Since it is very difficult to quantify such a measure, allocation to the sources with the lowest cost per tonne of reduction may be the best alternative. The cost element is composed of the direct cost of the reduction technology plus any secondary economic impacts of implementing the reductions, such as the loss of markets, or in the case of transportation, shifts between transportation modes.

In terms of environmental effectiveness, the following factors should be considered:

- Whether the reduction solves more than one environmental problem.
- The performance of the controls over their lifetime of operation, not just when they are new.
- The secondary impacts caused if restrictions on one sector cause growth in another one, which could result in a shift in emissions rather than a reduction.
- Seasonality considerations.
- New pollution generated in the production, installation or operation of technology or management approaches aimed at reducing NO_x or VOC.
- Whether emission rate reductions can be compared on an equivalent basis within an economic or industrial sector.

3. A Phase Approach

The management plan should combine short, medium and long term strategies so as to obtain a continuous improvement aimed at solving or preventing real problems. The timeline and commitments to reductions should be made public.

The timing of control actions should recognize the development of new technologies, the turnover of the existing plant and equipment, the type of use made of existing plant and equipment, and opportunities provided by modifications which need to be made to existing plant and equipment. Thus the allocation of reductions would take advantage of the opportunities which are available to facilitate reductions.

Included in the phase approach would be the opportunities for "mid-course corrections" to be made to the management plan should the need arise.

4. Policy Instruments

The management plan should consider the full range of policy instruments available. However, the choice of instruments should not influence the allocation of reductions, but rather it (the choice) should be made after the reductions have been allocated. Reductions should not be allocated to sources because they can be controlled by a favoured policy instrument.

5. Coordination

The allocation of reductions in the management plan should take into account other control strategies or approaches as well as existing and proposed regulation. Harmonization of federal and provincial regulation to avoid duplication and contradictions is also desirable.

6. Flexibility of Response

The method of allocation, and the resulting reduction requirements, should not restrict innovation or the flexibility to respond to changing conditions. In this regard, performance criteria are preferred to specified technologies.

7. Common Baseline

All control opportunities should be independently evaluated relative to a common baseline. Emissions in the baseline year should not serve as a basis for the allocation of reductions between sectors although it may be appropriate for national and international reporting. The allocation should accommodate actions being taken for other environmental problems.

8. Comprehensiveness

The management plan should allocate to all relevant sectors, as defined by their contribution to the ozone problem. Sectors which might have more difficulty in implementing reductions should be allowed more time (see principle #3, A Phased Approach) and/or special assistance in technology transfer, but should not be exempted from undertaking their share of reductions.

9. Prevention

The management plan should recognize that in order to prevent deterioration of air quality, national guidelines governing emissions from new sources should be prepared. These could be incorporated into regulation by provincial governments, which would also be able to impose more stringent requirements for the regions which require them. This approach would not exclude national standards if they are judged to be appropriate.

10. A Regionally Based Approach

The management plan should as a first step in the allocation of reductions attempt to find regional solutions to regional problems. Should these fail to meet national or international commitments, further reductions should then be sought.

11. A Broad Approach

The management plan should be broadly based so that solutions to environmental problems do not create or compound other environmental problems. The plan should take advantage of synergistic opportunities.

12. Econometric Models

Since the management plan will attempt to solve health and Environmental problems, the use of econometric models or techniques to assess the impacts of the plan should also attempt to assess the value of health and environmental improvements.

IV. 2 Approach to Preparing the Management Plan

The key steps followed in preparing the management plan were as follows:

1. The regions with the most serious ozone problems were examined in terms of:

i) the magnitude, geographic distribution and source types of NO_x and VOC emissions within the region.

ii) the reduction in ozone levels needed to achieve attainment with the maximum acceptable ozone concentration of 82 ppb.

iii) the relationship between the geographic distribution of NO_x and VOC sources and the pattern of elevated ozone concentrations, where possible.

iv) the relative effect of local versus imported pollutants on the ozone pattern in the region.

v) the probable effectiveness of NO_x versus VOC reductions at Canadians sources.

2. An evaluation was made of the NO_x and VOC reductions achievable in year 2005 nationally and in selected regional settings by implementing a set of nationally applicable initiatives:

i) a realistic set of fuel economy, energy efficiency and demand management measures (consistent with the anticipated thrust of control programs for greenhouse gases).

ii) a realistic set of product reformulation or substitution targets for products containing solvents.

iii) new source performance standards, based on state-of-the-art technology, to all new mobile and stationary sources of NO_x and VOC (consistent with the above listed principles of allocation and with the terms of the international NO_x protocol).

iv) public education initiatives to increase public awareness and public contribution to the solution.

3. Additional control measures were successively applied to existing NO_x and VOC emission sources in regions where ozone problems would obviously still remain after implementing the above measures nationally (or where new ozone problem areas might have been created because the national initiatives had not prevented significant increases in NO_x and VOC emissions from occurring).

The control measures considered for region-specific application included the full range of options: emissions control technologies, energy efficiency measures and demand management measures, product control and public education. Due consideration was given to cost effectiveness, the relative contribution of the source to the ozone problem and the potential effect on industry and the consumer.

4. A comprehensive set of NO_x and VOC reduction initiatives was developed incorporating both national and regional measures. These initiatives, along with the accompainying schedule and mechnism for implementation, constitutes the management plan.

V REGIONAL ANALYSES OF EMISSION REDUCTION REQUIREMENTS

V.1 RELATIONSHIP BETWEEN VOC/NO_X EMISSION REDUCTION AND REDUCTION IN OZONE CONCENTRATIONS

Before examining specific regional situations, it is useful to discuss the ozone formation process and ozone-precursor relationships. The following section briefly outlines some of the current state of knowledge of the relationship between NO_x and VOC emissions and ozone formation.

Ozone Formation Process

The formation of ozone in the troposhere is primarily controlled by three reactions. In the first reaction, NO_2, in the presence of sunlight, dissociates to form nitric oxide and a single oxygen atom.

$$NO_2 + h\nu \xrightarrow{K1} NO + O \quad (1)$$

The single oxygen atom reacts with atmospheric oxygen to form O_3.

$$O + O_2 \longrightarrow O_3 \quad (2)$$

A third reaction acts continuously to destroy ozone and regenerate NO_2.

$$NO + O_3 \xrightarrow{K2} NO_2 + O_2 \quad (3)$$

The steady-state concentration of ozone at a particular site depends on the following equation (Dodge, 1987):

$$[O_3] = \frac{K_1}{K_2} \times ([NO_2]/[NO]) \quad (K_1, K_2 \text{ are rate constants})$$

The ratio (K_1/K_2) is determined solely by the intensity of sunlight; it has a value of zero at night. In contrast, the ratio of NO_2/NO is sensitive to the presence of VOC, because these species are sources of free radicals

which can oxidize NO to NO_2. VOC then are doubly effective in amplifying ozone levels because they remove an ozone sink (NO) at the same time as creating an ozone source (NO_2) (Finlayson-Pitts and Pitts).

Ozone formation is said to be NO_x-limited when addition of NO_x results in higher ozone concentrations. However, the NO_x-limited condition is a function not only of NO_x, but also of the VOC concentration. The situation is illustrated in Figure 14, which plots O_3 as a function of NO_x with (VOC) as a parameter. The figure shows that O_3 increases with NO_x until it reaches a maximum, decreasing thereafter with further increases in NO_x. Whether ozone increases or decreases with increasing NO_x is determined by the VOC/NO_x ratio. The figure shows that for VOC/NO_x ratios greater than about 4.8, ozone will be in the NO_x-limited condition, and vice versa. The precise VOC/NO_x ratio that forms the boundary of the NO_x-limited region will vary depending on the type of hydrocarbons involved (the curves in Figure 14 are for a mixture of propylene and n-butane), so no special significance attaches to the ratio of 4.8. Nevertheless, atmospheric values of VOC/NO_x > 10 generally lead to NO_x-limited conditions for O_3 formation (U.S. DOE 1983). Thus, a high VOC/NO_x ratio is a necessary condition for ozone to be in the NO_x-limited region. Observations of VOC/NO_x ratios and mean VOC/NO_x concentrations at Canadian urban and rural sites are given in Table 6.

VOC and NO_x levels and susquent VOC/NO_x ratios can vary from ozone episode to episode, from city to city and across urban areas. As polluted air masses are transported, chemical and physical processes remove NO_x more rapidly than VOC's resulting in an increase in VOC/NO_x ratios. NO_x reductions generally become more effective in reducing ozone concentrations downwind of high emission regions over suburban and rural areas.

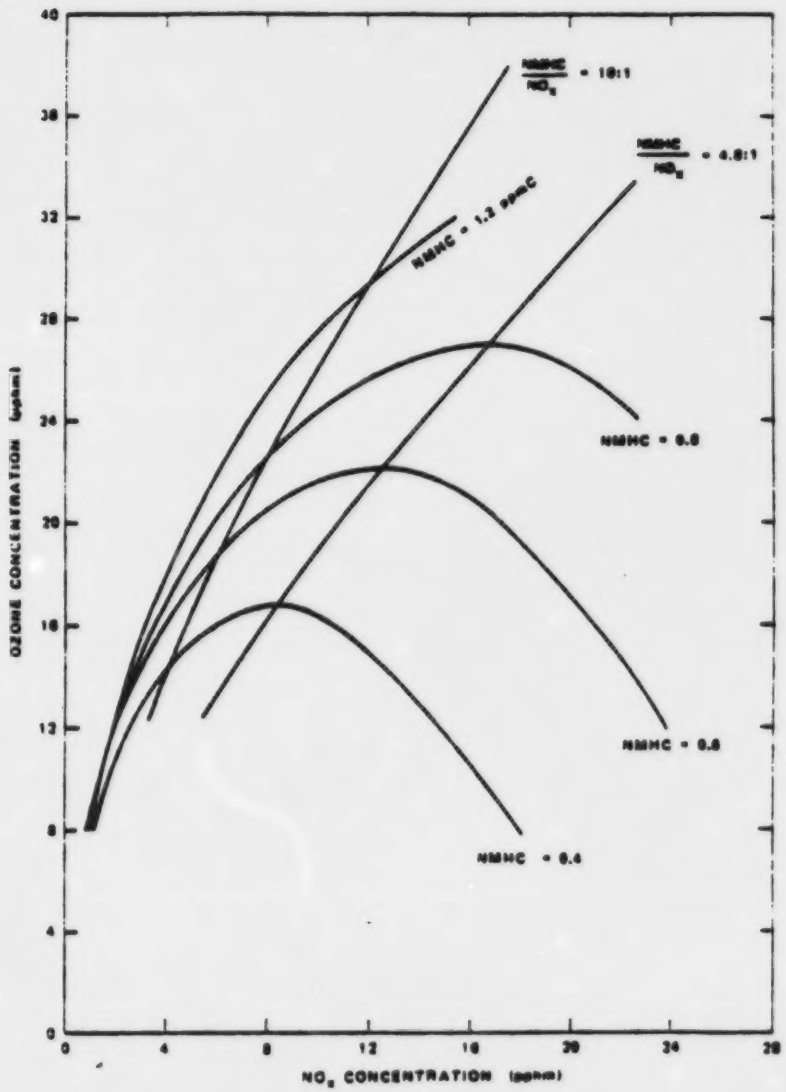


FIGURE 14 OZONE CONCENTRATION AS A FUNCTION OF NO_x LEVEL WITH NONMETHANE HYDROCARBON (NMHC) AS PARAMETER

TABLE 6 RATIOS OF NON-METHANE VOCS TO NO_x

City	VOC/NOx Med.	VOC/NOx Max.	VOC/NOx Min.	Mea VOC (ppbC)	Mea NOx (ppb)	Sampling Dates	No. of Samples	Reference
URBAN								
Toronto 1 (Queen's Park)	9.5	12.7	8.3	702	67	July-Oct. 1987	9	Dann, 1989a
Stouffville 1	17.3	34.1	10.9	380	20	July-Oct. 1987	16	Dann, Personal Communication
Hamilton 2	7.5	11.2	3.3	325	41	April-June 1989	9	Dann, Personal Communication
Sarnia	15.1	76.5	3.4	---	---	-----	---	Reid/Wong, 1988
Sarnia 2	6.4	11.4	3.2	154	23	April-May 1989	7	Dann, Personal Communication
Windsor 2	9.7	41.6	4.1	400	48	July-Dec. 1987	20	Dann, 1989a
	10.3	26.6	4.6	382	33	April-May 1989	7	Dann, Personal Communication
Montreal -Ontario St. 2	8.7	27.5	2.4	416	47	April-June 1989	8	
Point aux Trembles	11.9	14.5	7.3	332	31	April-June 1989	7	
Vancouver -Burnaby South 3	11.8	16.1	4.0	410	53	Aug.-Oct. 1987	9	Dann, 1988a
-Burnaby South 4	6.9	5.6	14.5	321	64	Aug.-Dec. 1988	10	Dann, 1989c
Vancouver -Burnaby North 3	15.1	63.8	3.5	931	75	Aug.-Oct. 1987	23	Dann, 1989a
Vancouver -Kitsilano 4	3.6	4.4	5.0	193	53	Aug.-Dec. 1989	5	Dann, 1989c
Vancouver 2 -Rocky Point Park	6.8	9.5	5.9	353	63	March-April 1989	9	Dann, Personal Communication
Rural								
Walpole Island 2	---	---	---	198	--	Jan.-Sept. 88		
Durget/Egbert 5		7-->40		32	1-4	Aug. 88		

1. Samples Collected 6-9 am or 7-10 am
2. 24 hour sampling once every six days
3. Samples Collected 3-7 am or 6-9 pm
4. Samples collected 6-9 am
5. Instantaneous samples collected on December 20, 1989 (ASCA)A/613

Ozone-Precursor Relationships

General

The complexity of the atmospheric processes resulting in ozone formation cannot be overstated. The complexities stem from the fact that ozone is an extremely reactive pollutant and can be scavenged by the same pollutants (i.e. NO, some VOC) that produce it (Dimitriades 1988). Theoretically, relationships between ozone and its precursor can be derived from laboratory smog chambers, from urban and regional scale photochemical models, from field monitoring studies and from empirical multi-year historical data relating emission trends to observed changes in ozone. In practice, due to the severe limitations in empirical evidence, most accepted ozone to precursor relationships are derived form modelling evidence (Dimitriades 1988). Modelling evidence in turn is affected by the accuracy of chemical/transport mechanisms used to simulate the real atmosphere, accuracy of ambient precursor concentration data, accuracy of emission data and adequacy of treatment of transport of ozone and precursors. Some details of existing models and results of model scenarios are contained in the report of the NO_x/VOC Workgroup on Modelling.

Urban Modelling

Most urban modelling results are based on the Empirical Kinetic Modelling Approach (EKMA) and have focussed almost exclusively on VOC reduction as a control technique. EKMA is considered most appropriate for isolated urban areas with simple topography, uniform emission distributions and with moderate ozone problems. Some examples of relationships between % VOC reduction and % ozone reductions derived from EKMA are given in Tables 7 and 8.

Most EKMA results would suggest that VOC reduction are more beneficial than NO_x reductions at ambient VOC/NO_x ratios < 8:1. However, EKMA results show that a reduction in either or both NO_x and VOC will reduced peak ozone levels.

TABLE 7 PEAK OZONE VS PRECURSOR REDUCTIONS AT DIFFERENT VOC/NO_x RATIOS (FRIEDMAN ET AL 1988)

	Emission Reduction	Reduction in Peak 03
Medium VOC/NOx Ratio	- 35% VOC	- 13%
	- 35% VOC, - 35% NOx	- 20%
Low VOC/NOx Ratio	- 35% VOC	- 26%
	- 35% VOC, - 35% NOx	- 20%
High VOC/NOx Ratio	- 35% VOC	- 9%
	- 35% VOC, - 35% NOx	- 20%

TABLE 8 ESTIMATED OZONE REDUCTIONS FROM ONE PERCENT REDUCTION IN VOLATILE ORGANIC CARBONS EMISSIONS FOR SELECTED CITIES IN THE U.S.A.* (PrATAPAS AND CALCAGNI 1983)

City	% 03 Reduction / % VOC Recuction
Boston, MA	0.7
New York, NY (NY-NJ-CT)	0.9
Philadelphia, PA (PA-NJ-DE)	0.8
Baltimore, MD	0.7
Washington, DC (DC-MD-VA)	0.9
Houston, TX	1.4
St. Louis, MO	0.7
Salt Lake City, UT	0.8
Los Angeles, CA	0.9
Fresno, CA	0.8
Ventura, CA	0.7
San Diego, CA	1.1

* From SIP design data. Modeling parameters current as of April 21, 1983; emission inventory current as of February 1983.

TABLE 9 RESULTS FROM REGIONAL OXIDANTS MODEL (ROM) SCENARIOS (NO_x/VOC WORKGROUP ON MODELLING)

ROM Scenario	Reduction in number of Cells > 120 ppb (Washington, NY, Conn., Boston)
VOC -20%, NOx - 2%	-28 to -41%
VOC -56%, NOx - 2%	-65 to -71%
VOC -49%, NOx -33%	-73 to -95%

(% Reduction in peak hours not available)

TABLE 10 RESULTS FOR SAJ REGIONAL OZONE MODEL APPLIED TO NORTHERN EUROPE (FRG AND NETHERLANDS 1989)

PHOXA AREA	No. of Grid Hours O_3 (ppb) > 60	>80	>100	>120
BASE	24,445 (34.6%)	9406 (13.1%)	1964 (2.8%)	62 (0.1%)
max VOC - 48% VOC - 24% NO_x	(-2%)	(-12%)	(-32%)	(-81%)
Max NO_x - 54% NO_x - 18% VOC	(-5%)	(-33%)	(-67%)	(-100%)
Max NO_x & Max VOC - 54% NO_x - 48% VOC	(-8%)	(-40%)	(-75%)	(-100%)

Reduction in grid hours >96h simulation

Regional Scale Models

The U.S. EPA Regional Oxidants Model (ROM) has been the most extensively applied regional model. Southern Ontario is included in the model domain. Results from ROM suggest that VOC reduction will reduce peak ozone levels, with the largest reductions occuring in the areas of highest ozone concentrations (U.S. EPA 1986, Lamb 1987). Most available ROM results are for VOC reduction scenarios with only modest NO_x reductions being evaluated. Table 9 contain a summary of results. ROM results suggest that very large emission reductions (>60%) would be required to reduce ozone levels below the U.S. primary standard of 120 ppb in northeastern North America (NO_x/VOC Workgroup on Modelling).

Regional models have also been applied Europe. Northern Europe experiencer similar ozone maxima to those recorded in the WQC. As shown in Table 10 the Eurpoean modelling effort suggests that combined - VOC/NO_x reduction would result in the largest ozone reductions. Emission reductions of greater than 75% VOC and 75% NO_x would be required to reduce peak ozone below 80 ppb in all areas of northern Europe based on model results. (FRG 1989, Zierock 1988)

Rural Models/Transport of Ozone

The Regional Oxidant Model has shown that the bulk of the ozone attributable to anthropogenic sources is generated within about 100 km of the major urban areas and that beyond distances of about 200 km, ozone is primarily in a state of decay (EPA 1986, Lamb 1987). Most areas of the eastern United States, including rural areas, were shown to be net exporters of ozone due to local generation of ozone. This local generation of ozone is due to imported and locally produced precursor species.

The University of Harvard has developed a model with the capability of predicting ozone levels in rural areas (Sillman et al 1987). The model has been applied to the north-eastern U.S. and to southern Ontario and indicates that concentrations of precursor in rural air are sufficient to produce significant levels of photochemical oxidants. Rural ozone appears to be

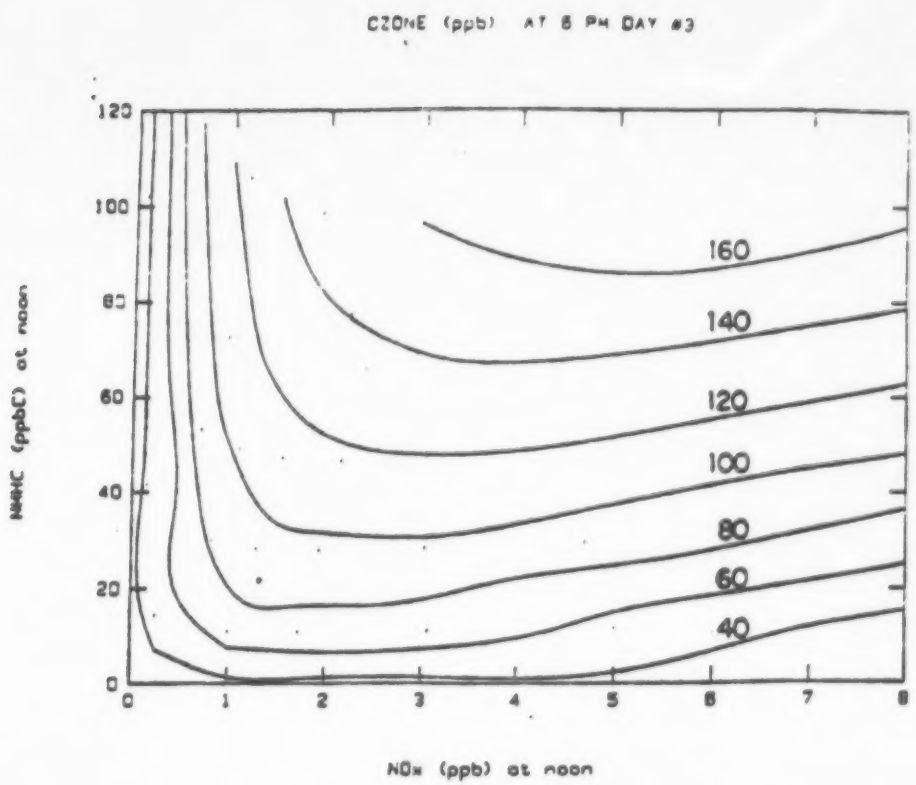


FIGURE 15: (A) RURAL SENSITIVITY STUDY: OZONE (ppb) AT 6 pm VERSUS NOON NO_X AND ANTHROPOGENIC NMHC CONCENTRATIONS ON DAY 3. RESULTS ARE FROM A SERIES OF SIMULATIONS WITH NO ISOPRENE EMISSIONS. (B) SAME AS (A), PLOTTED AGAINS 24-HR MEAN NO_X EMISSION RATES INSTEAD OF NO_X CONCENTRATIONS. (Sillman et al 1987)

generated from the interaction of anthropogenic hydrocarbons and anthropogenic NO_X and from biogenic hydrocarbons and anthropogenic NO_X. Relationships between O_3 and precursors from the model for a three day simultation are shown in Figure 15. The results shown that with rural NO_X levels below 1 ppb, production of O_3 will be small even if substantial amounts of hydrocarbon are present. Under these conditions elevated O_3 levels can only occur by transport form urban areas. However, at higher levels of NO_X, substantial O_3 concentrations can be generated at modest levels of hydrocarbons. Observations at two sites north of Toronto, Englehart and Dorset in August, 1988, showed that anthropogenic VOC

concentrations averaged ~30 ppbC and NO_x (NO_2) averaged of 2-5 ppb. In the eastern U.S. rural NO_x concentrations are typically greater than 1 ppb and rural anthropogenic VOC concentratons range from 20 to 100 ppbC (Sillman et al 1987).

Both the ROM and Harvard results suggest that episodes of high O_3 in eastern North America can develop, fuelled by photochemical production form precursors present in rural air. Because of much lower NO_x emissions, this process appears to be unlikely in western rural areas.

A regional model of NO_x for eastern North America predicts annual average NO_x ($NO + NO_2$) levels in most of eastern Canada in the range of 8-12 ppb (Fay et al 1987). The model also suggests that significant transport of NO_2 can occur in the atmosphere, and that concentrations of NO_2 in most areas of Eastern Canada are due to distant sources.

SUMMARY

1. Ozone reductions will be less than proportional to reductions in VOC and/or NO_x.

2. For most situations, VOC reductions will reduce peak concentrations near major source areas. Effectiveness is a function of VOC/NO_x ratio, VOC/NO_x concentrations, meteorology and mixing heights. In most situations the highest ozone concentration will occur during mid afternoon about 50 km downwind of source areas.

3. Rural ozone production in rural areas of eastern Canada may be NO_x limited. Large reductions in NO_x would be necessary to reduce O_3 peaks.

4. Simultaneous reduction of VOC/NO_x appears to be the best startegy to achieve the goal of zero hours >82 ppb and reduce other problems association with VOC and NO_x.

5. Additional modelling will be needed to fine-tune emission control scenarios.

V.2 REGIONAL ANALYSES

Three geographic regions were analyzed for reductions needed to achieve attainment with the Canadian maximum acceptable ozone objective of 82 ppb, magnitude and areal distribution of NO_x and VOC sources, influence of imported pollutants, and possible merits of NO_x versus VOC control. The regions analyzed were:

- Lower Fraser Valley (LFV)
- Windsor-Quebec Corridor (WQC)
- Saint John Area (SJA)

a) Lower Fraser Valley (LFV) Region

Size and Location

This region consists of four Census Divisions:

Greater Vancouver Regional District
Central Fraser Valley Regional District
Dewdney-Allouette Regional District
Fraser-Cheam Regional District

The total population of the region is 1.53 million or 53% of the population of British Columbia.

Extent of Problem

Monitoring results show that during typical episodes, ozone levels build up from the coastline at the west boundary of Vancouver to the head of Burrard Inlet where they peak and then very gradually decline inland up the Fraser Valley.

Some of the highest hourly maximum ozone counts for the country have been measured in the Lower Fraser Valley, although occurrence of levels >82 ppb are much less frequent than in the WQC (See Figure 3). Boxplots of maximum ozone and hours->82 ppb by year for all eastern and rural (Fraser

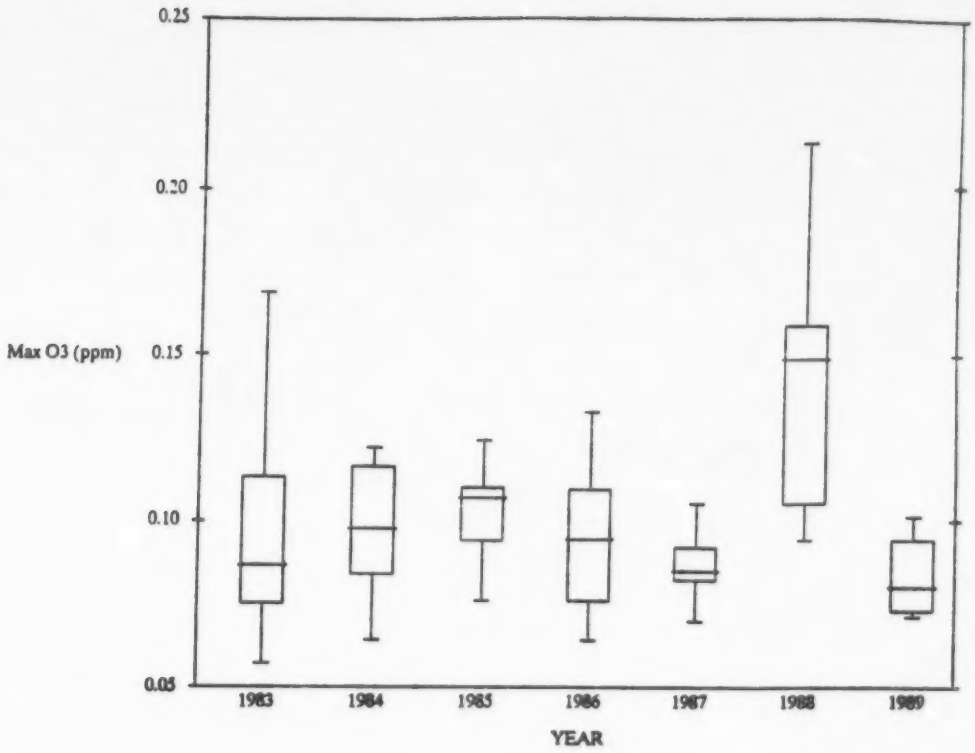


FIGURE 16 MAXIMUM OZONE-WEST GVRD AND LOWER FRASER VALLEY (1983-1989)

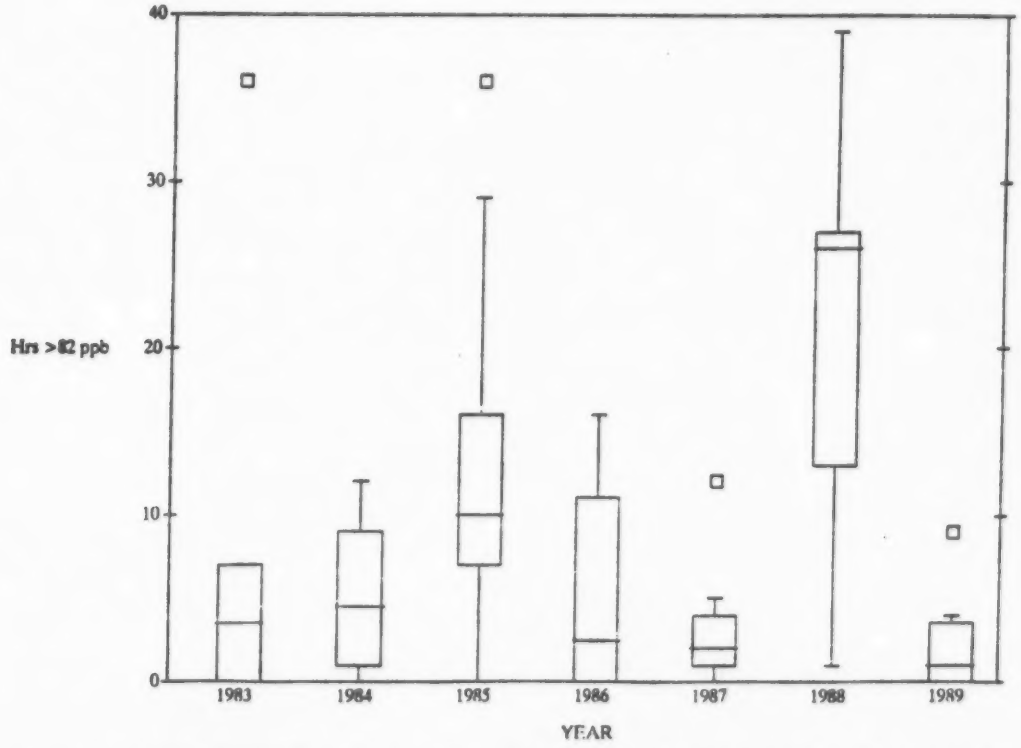


FIGURE 17 OZONE HOURS PER YEAR >82 ppb-WEST GVRD AND LOWER FRASER VALLEY

Valley) GVRD sites are given in Fig. 16 and 17. Based on the average maximum ozone values (3 highest years 83-89) measured at sites near Port Moody/Port Coquitlam, reductions in peak ozone concentration of >40% will be required to achieve the 82 ppb objective (see Appendix D). Although ozone peaks decline eastward through the valley, a 25% reduction in peak ozone would still be required as far east as Chilliwack in order to meet the 82 ppb air quality objective.

Meteorology/Transport

Ozone episodes in the LFV appear to be associated with the formation of a sea breeze, resulting in low mixing heights and channelling of GVRD emissions eastward up the Burrard Inlet (Davis et al 1984, Concord and Levelton 1989). High inland temperatures, clear skies and stagnant weather systems are a common meteorological feature of episodes.

The LFV shares a common airshed with parts of the State of Washington to the south. One analysis of ozone episodes (Coligado 1988) has suggested that precursor and ozone transport for the Puget Sound area of Washington State might influence the LFV airshed. It is unlikely, however, that long range transport is a significant contributor to the very high peak ozone levels measured at times in the Port Moody area.

VOC/NO_x Observations

A substantial amount of 24 hour, 3 hour and 6 hour VOC and NO_x data has been collected in the GVRD, although most of it was collected for purposes other than ozone control strategy formulation (see Table 6). Median VOC/NO_x ratios measured at GVRD sites were variable ranging from 4 to 15.

Modelling Results

The only modelling results available for the LFV are from a limited EKMA analysis carried out under contract in 1988 (Concord and Levelton 1989). The results indicated that a VOC control strategy would be the most optimum approach for reducing ozone levels in the GVRD. Because of the limitations

involved in applying EKMA to an airshed as complicated as the LFV and because of inadequacies in input data for the model runs, these results should be treated with caution.

Emissions

Emissions of NO_x and VOCs in the LFV region in 1985 and 2005 are estimated to be as follows:

	Emissions (KT) 1985	2005	% Change
NO_x			
Mobile	73.1	45.3	-38%
Stationary	19.6	32.0	+64%
Total	92.7	77.4	-17%
VOC			
Mobile	61.4	43.8	-29%
Stationary	52.7	64.8	+23%
Total	114.1	108.6	-5%

Differences between these estimates and other emission estimates for the Lower B.C. Mainland will be resolved before the plan is finalized.

Despite significant reductions in both NO_x and VOC emissions from mobile sources, only modest overall reductions in the two precursor pollutants occur due to offsetting increases in stationary sources emissions. Examination of the source data indicates that the increase in stationary source NO_x is due primarily to industrial processes and industrial fuel combustion. The increase in VOC emissions is due primarily to industrial processes and solvents. In 2005, the 5 largest sources of NO_x and VOCs will be:

NO_x Source	NO_x(kt)	% of Total
Light Duty Vehicles	16.5	21
Heavy Duty Vehicles	16.1	21
Industrial Processes	15.5	20
Industrial Fuel Combustion	10.7	14
Off-Road Diesel	8.1	10
	66.9	86

VOC Source	VOC(kt)	% of Total
Solvents	32.5	30
Light Duty Vehicles	26.7	25
Industrial Processes	11.3	10
Marine	6.5	6
Gasoline Distribution	6.1	6
	83.1	77

Required Emission Reductions

In the absence of definitive model results and based on the discussion in Section V.1, it is assumed that both NO_x and VOC reductions would be effective in reducing peak ozone concentrations in the GVRD and downwind areas of the Fraser Valley. Measured VOC/NO_x ratios suggest that the GVRD would be considered to be in the intermediate range. Also because there is limited imported NO_x and VOCs to the region, it is assumed that percentage reductions in NO_x and VOC emissions will result in equivalent percentage reductions in ambient air concentrations of NO_x and VOCs and less than a one to one reduction in ozone will occur with any given reduction in VOCs and/or NO_x.

Given these assumptions, the following NO_x and VOC reductions would be needed to bring average peak O_3 levels in the LFV region consistently down to 82 ppb:

i) 50-60% reduction in VOCs
   No reduction in NO_x
ii) 50-80% reduction in NO_x
   No reduction in VOCs
iii) 40-50% reduction in VOCs
   40-60% reduction in NO_x

To reduce worse case peak ozone levels to 82 ppb, even larger percentage reductions will be required.

b) Windsor-Quebec Corridor (WQC)

Size and Location

The WQC region, for the purpose of this analysis, represents a narrow strip of land (about 100 km wide) along the north shores of Lake Erie, Lake Ontario and the St. Lawrence River in Quebec, and straddling the St. Lawrence River from the Ontario border to Quebec City in Quebec. The region included

is outlined in Figure 18, which also shows the major VOC and NO_x source areas near the Great Lakes. The WQC region contains 85% (7,757,000) of Ontario's population and 64% (4,183,000) of Quebec's population.

Extent of Ozone Problem

Figure 19 shows a profile of maximum ozone concentrations and hours >82 ppb along the corridor superimposed on bar graph displays of NO_x and VOC emissions in 1985. Box plots showing the variation in peak ozone concentration by year are given in Figure 20. Reductions in peak ozone of 35-50% are needed throughout most of the region from Windsor to Oshawa, and 30 to 40% reductions are needed from Oshawa to Quebec City.

Metheorology/Transport

Occurrences of high ozone in the WQC are strongly associated with periods of high temperatures. Figure 21 shows a plot of number of days with maximum temperatures greater than 32°C vs average maximum ozone and average hours>82 ppb for 31 sites in Southern Ontario for the period 1983-1989. For Toronto, the number of days >32°C is typically about 20 based on 1950-1988 meteorological records. In turn, high temperature days in WQC are associated with stagnating high pressure systems that maintain clear skies and high temperatures (see Section II.3(d)). These weather systems result in predominently southwesterly flows through the region.

A number of areas in Southern Ontario are close to major U.S. emission sources and during southwesterly flow could be within the high ozone plumes associated with these areas (see Figure 18). Back trajectories for 28 episode days occurring in Ontario between 1987 and 1989 show that in all cases air parcels had passed over Michigan and/or Ohio within 6 to 12h of their arrival at London, Ontario (midway between Toronto and Windsor). Apart from direct ozone impacts, increases in precursor concentrations, especially NO_x, in rural areas of Ontario due to U.S. emissions may be very important in rural ozone formation processes.

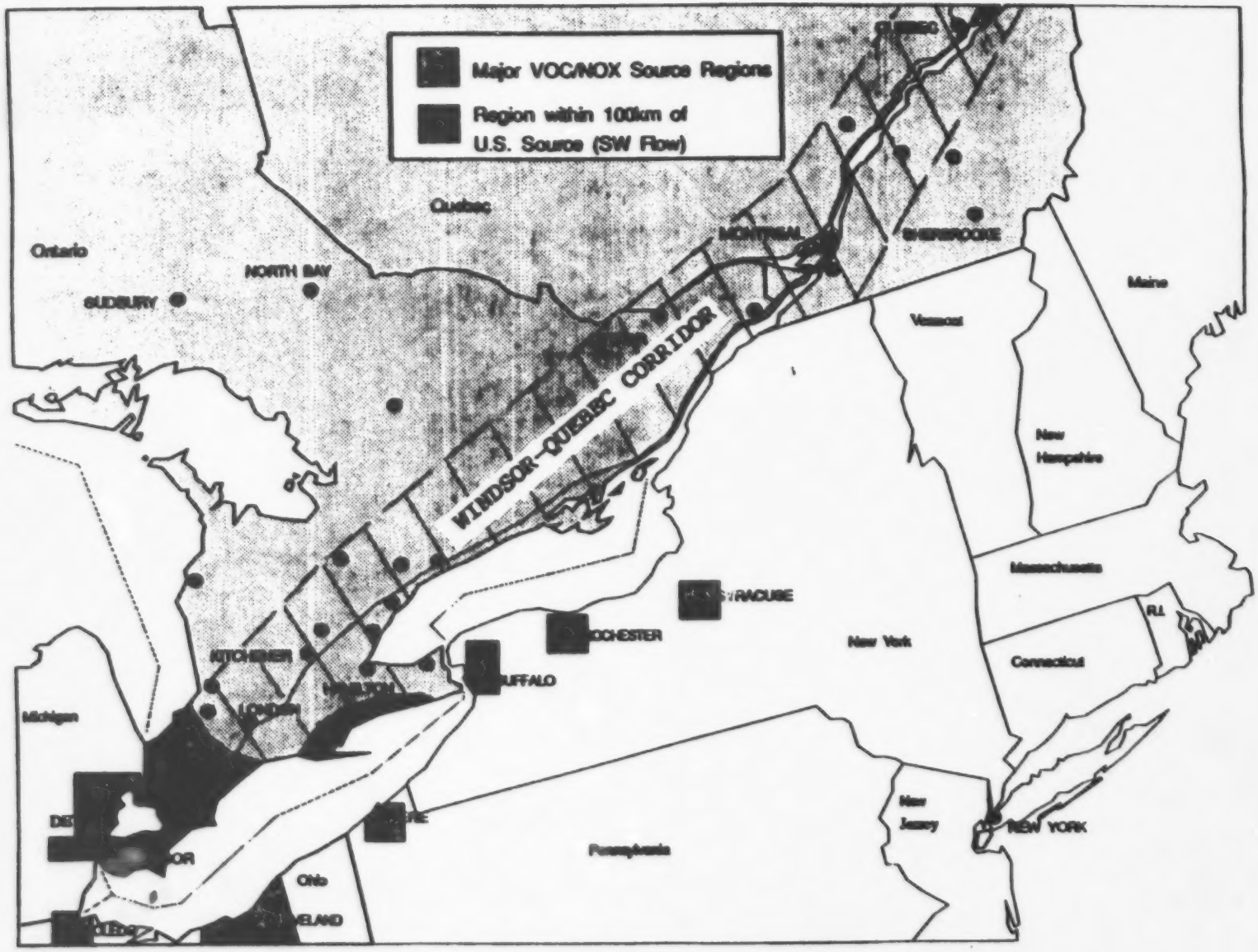
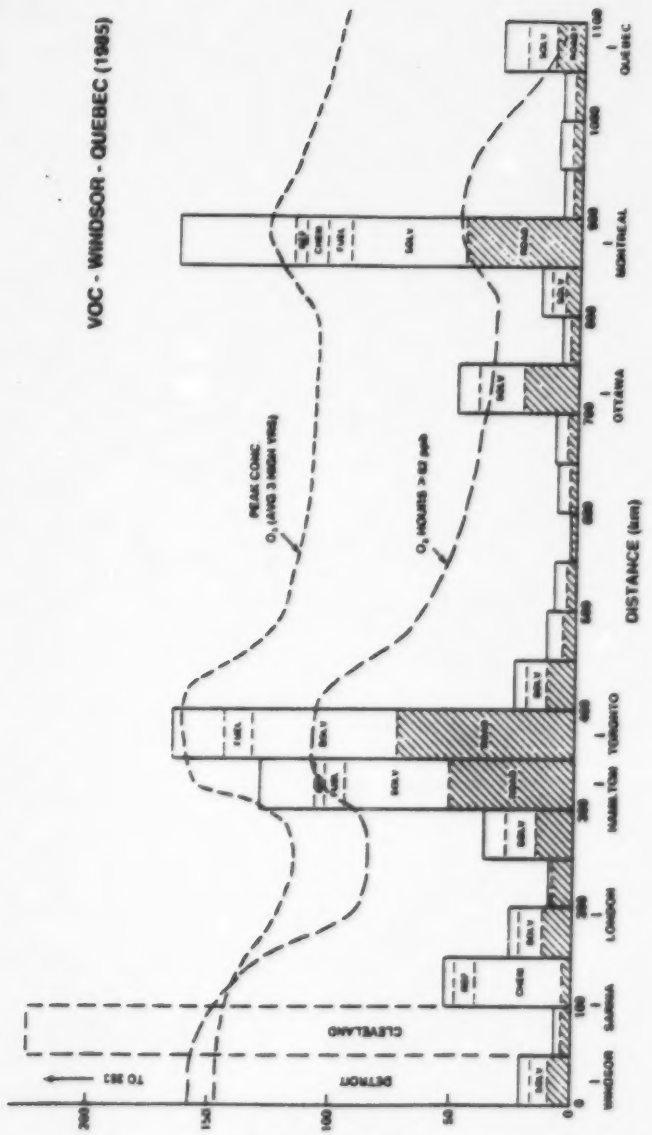


FIGURE 18 WINDSOR-QUEBEC CORRIDOR AND LOCATION OF MAJOR U.S. VOC/NO_x SOURCE REGIONS NEAR GREAT LAKES



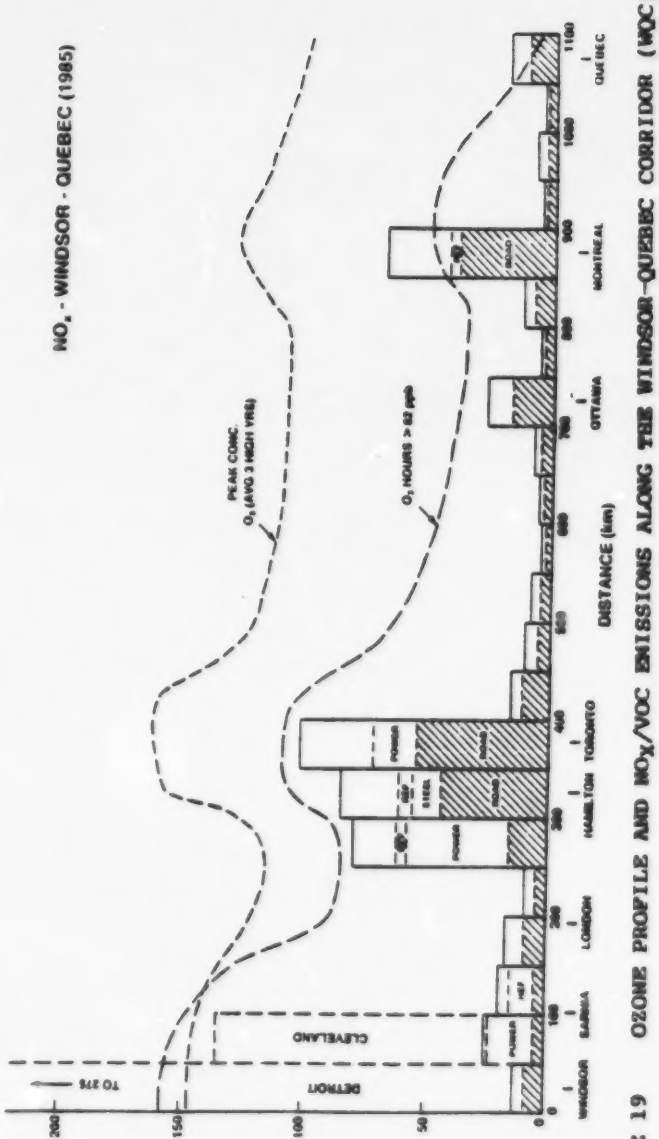


FIGURE 19 OZONE PROFILE AND NO_X/VOC EMISSIONS ALONG THE WINDSOR–QUEBEC CORRIDOR (WQC)

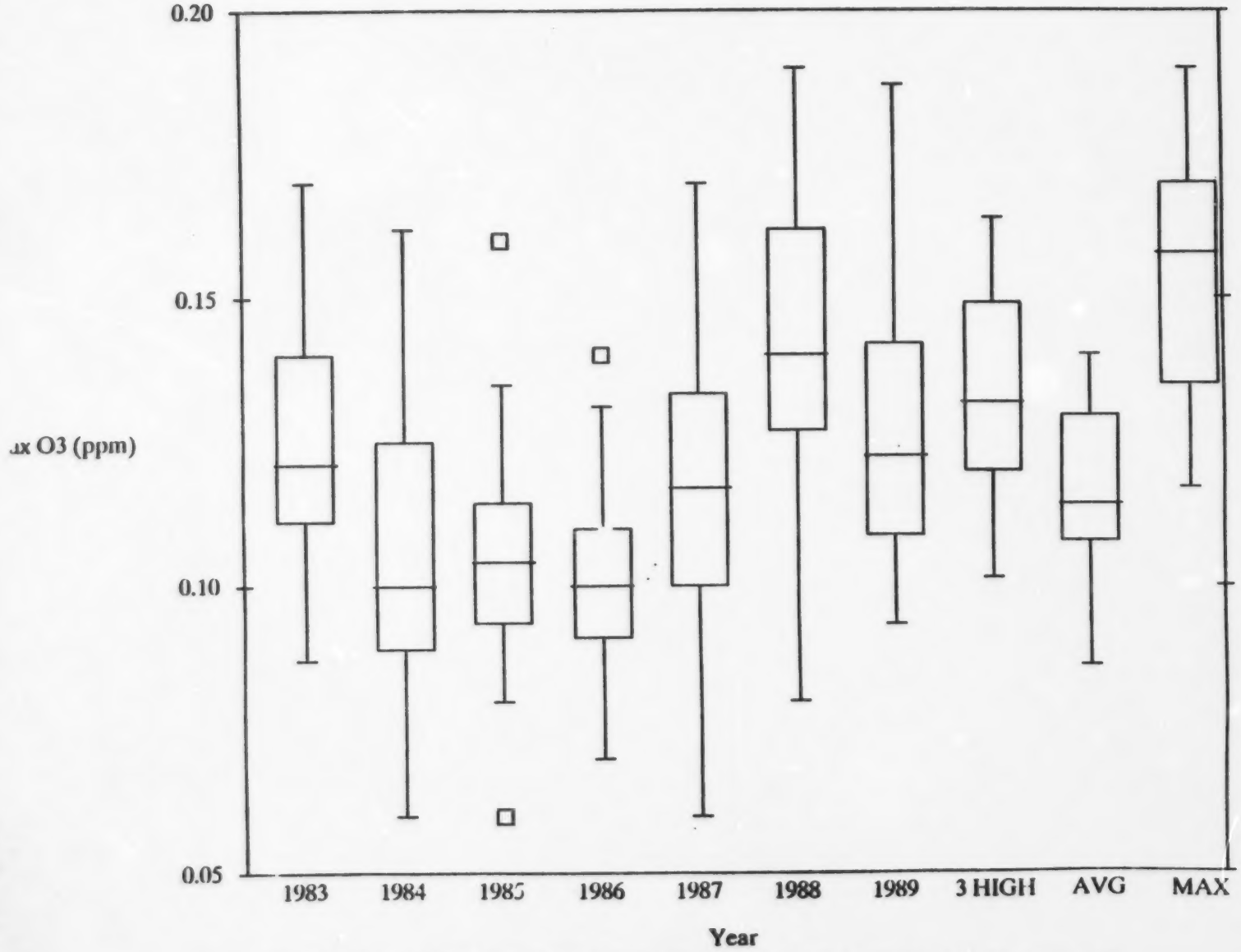


FIGURE 20 MAXIMUM OZONE CONCENTRATIONS 1983-89 IN WINDSOR-QUEBEC CORRIDOR

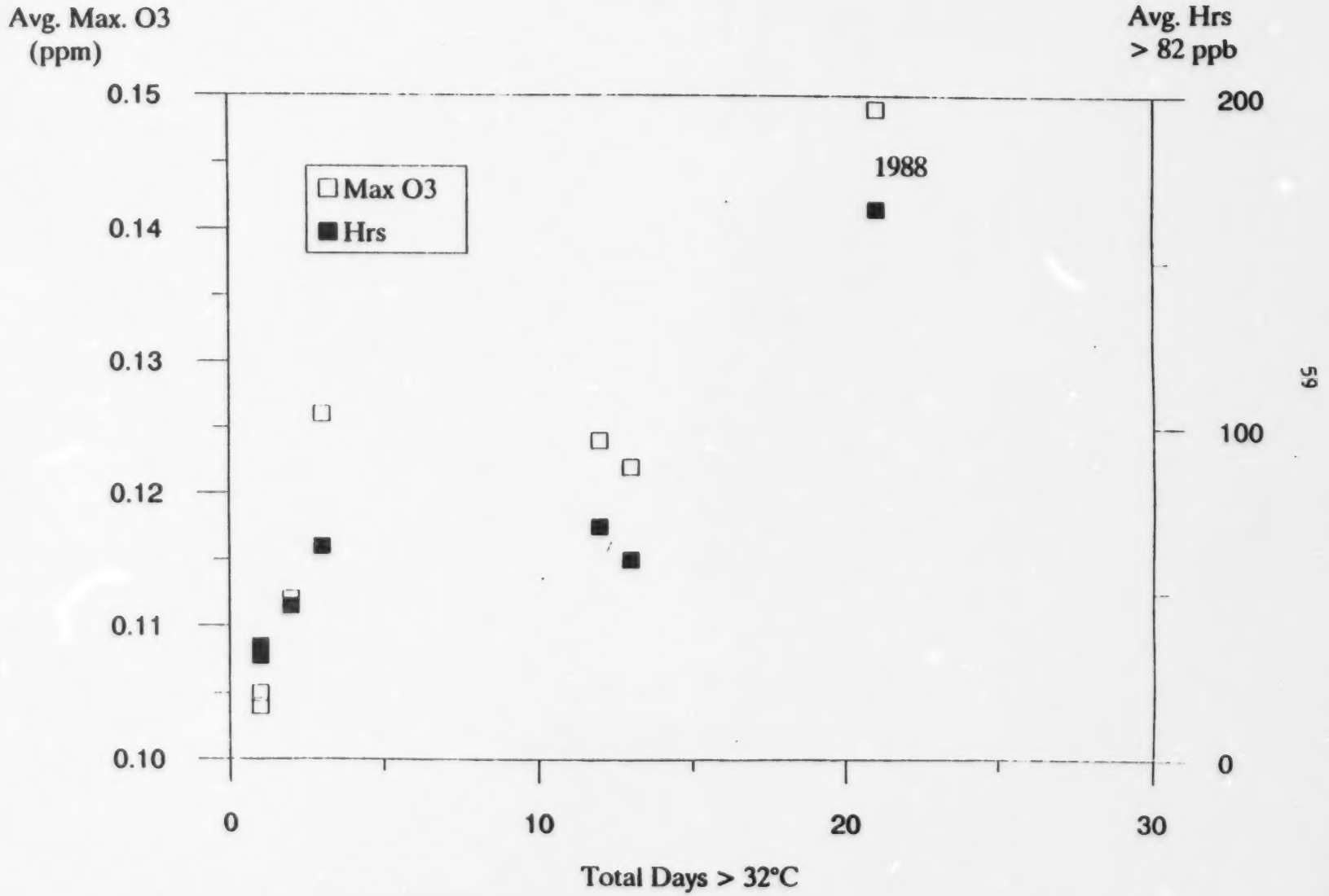


FIGURE 21 RELATIONSHIP BETWEEN DAYS WITH MAX. TEMP. >32°C AND AVG. MAX. O_3/DAYS > 82 ppb - ONTARIO (1983-89)

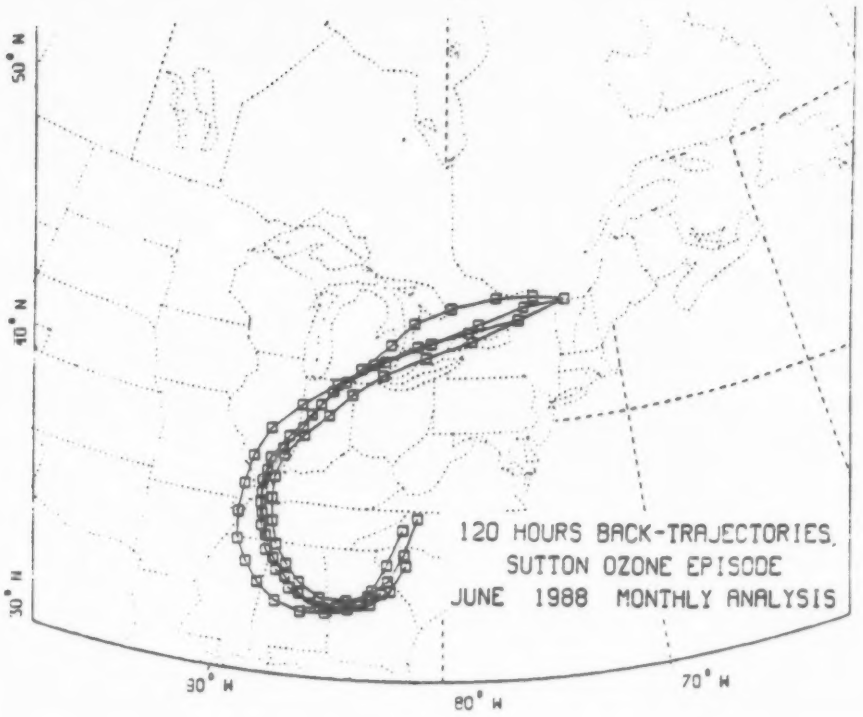
The Montreal-Quebec area is much further removed from high U.S. emission source regions. Back trajectory analyses of 15 Montreal episodes occurring in 1987, 1988 and June 1989 show that in 5 cases, air parcels arrived from the southwest after passing over Michigan, Hamilton, Toronto and the St. Lawrence Valley. In 4 cases, air parcels carried from south of Lake Ontario, passing through Buffalo and northern New York states. Only in the last 4 cases were travel times to U.S. source regions less than 24h.

Figure 22 shows typical back trajectories for ozone episodes in London, Ontario and Montreal, Quebec.

Quantifying the impact of U.S. emissions on Ontario/Quebec ozone levels is very difficult. The impacts would be expected to diminish as one moves eastward through the corridor due to increasing distance from U.S. sources, and the influence of the large VOC/NO_x emissions associated with the Hamilton-Toronto and Montreal urban areas. This tends to be confirmed by the declining profiles of ozone peaks and hours >82ppb in Figure 19.

Some observations about the apparent impact of various U.S. and Canadian emission sources on the O_3 profile can be made from Figure 19. At the Windsor end of the corridor O_3 peaks appear to be almost entirely due to U.S. sources. Fairly large point source VOC emissions at Sarnia cause only a minor bump in the emission profile and seem to have limited effect on the O_3 profile downwind. On the other hand, Hamilton-Toronto area emissions creat a large bulge in the profile and appear to have a significant effect downwind, probably all the way through to Montreal. A second significant bulge is created in the profile at Montreal, from which residual effects appear to carry downwind to Quebec City and beyond.

Peak ozone levels in Southeastern Ontario and along Lake Erie and Lake Huron are undoubtedly due almost entirely to U.S. emissions.



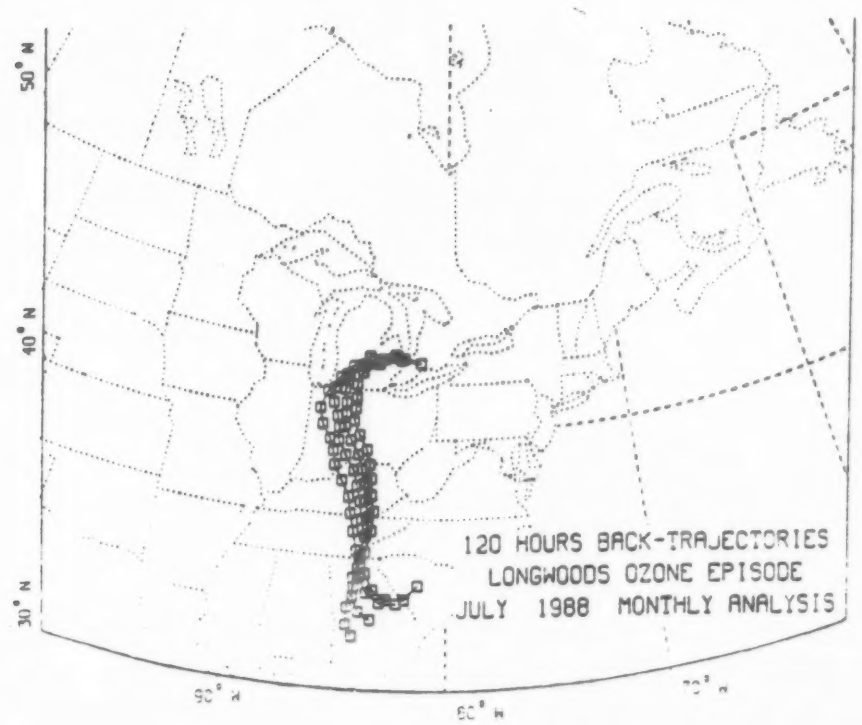


FIGURE 22 BACK TRAJECTORIES FOR OZONE EPISODES IN THE WINDSOR-QUEBEC CORRIDOR

VOC/NO_x Observations

A limited date base of urban VOC and NO_x measurements is available for the WQC. Limited rural data for VOC is available for two sites only (see Table 6). Very few observations of rural NO_x are available, although as discussed in Section V.1, rural NO_x levels are probably high enough to result in local generation of ozone throughout the corridor.

Modelling Results

Results for ROM showed a limited impact in Ontario of U.S. VOC emission reductions (U.S. EPA 1986, Fay et al 1987). Some reductions in peak ozone in southeastern Ontario would result due to reduced VOC emissions in the Detroit and Cleveland areas. No scenarios related to reduced emissions in Ontario have been evaluated using ROM.

Some emission reduction scenarios have been carried out using the ADOM model. Results from this model suggested little benefit from Ontario emission reductions of VOC and the greatest benefit from U.S. NO_x emission reductions (NO_x/VOC Workgroup on Modelling). Because the model was not been fully evaluated and because of the very coarse resolution of the model, these results should be treated with caution.

Emissions

Emissions of NO_x and VOC in the WQC in 1985 and 2005 are estimated as follows:

	Emissions (KT) 1985	2005	% Change
NO_x			
-mobile	359.5	309.7	-14%
-stationary	202.9	246.1	+21%
Total	562.4	555.8	-1%
VOC			
-mobile	264.2	211.9	-20%
-stationary	460.8	623.6	+35%
Total	725.0	835.5	+15%

Most of the NO_x stationary source emission increase comes from offroad diesel engines and industrial processes. The largest contributors to the increase in stationary source VOCs are solvents, and industrial processes, each responsible for about 40% of the increase. The remainder is distributed among many sources ranging from gasoline distribution to fuelwood combustion. The five largest NO_x and VOC sources in the WQC in 2005 are estimated to be:

NO_x Source	NO_x(kt)	% of Total
Light Duty Vehicles	99.7	18
Power Generation	93.4	17
Heavy Duty Vehicles	87.2	16
Off-Road Diesel	72.8	13
Industrial Fuel Combustion	66.8	12
	419.9	76

VOC Source	VOC(kt)	% of Total
Solvents	294.0	35
Industrial Processes	194.2	23
Light Duty Vehicles	147.7	18
Fuelwood Combustion	63.9	8
Gasoline Distribution	57.4	7
	757.2	91

Required Emission Reductions

With the suspected heavy influence of U.S. emission sources on O_3 levels along the corridor, but lack of specific information on how much of the NO_x, VOCs and O_3 observed in ambient air samples at different locations actually originates from the U.S., estimating the effectiveness of Canadian NO_x and VOC controls is difficult. It is assumed that in the Windsor area, where almost all NO_x, VOCs and O_3 originates from U.S. sources, that Canadian controls will do little to solve the ozone problem. As you move downwind along the corridor, the contr of Canadian NO_x and VOC sources should become increasingly effective. This includes control of Canadian sources of NO_x and VOCs in the Windsor end of corridor which add to the pollutant load in

incoming northeasterly flowing air masses from the United States, and The information available suggests that ozone reductions in urban areas would best be achieved by a combination of NO_x and VOC reductions, with NO_x reductions possibly being slightly more effective. NO_x reductions would become even more effective in reducing ozone levels in rural areas downwind of major urban centres where situations tend to be NO_x limited. A percentage reduction in NO_x and VOC emissions would not translate into an equivalent percentage reduction in ambient air NO_x and VOCs.

In order to achieve the 30-50 percent reductions in ozone peaks needed to meet the 82 ppb air quality objective, combined imported and domestic precursor reductions of 50-75% would be needed along the WQC based on the information in Tables 7 and 8. Reductions in imported NO_x and VOCs of 30-50 percent may occur over time with the U.S. Clean Air Act amendments. Similar reductions from Canadian sources could be a significant step towards resolving peak ozone problems in the WQC.

c) Saint John Area (SJA)

Size and Location

The SJA, for the purposes of this analysis, is represented by two counties in southern New Brunswick, Saint John County and Kings County, with a combined population of 139,058 (20% of New Brunswick).

Extent of Ozone Problem

Ozone monitoring data in the SJA suggests that O_3 reductions in the range of about 30% would be required to achieve attainment with the 82 ppb ozone objective (see Appendix D).

Meteorology/Transport

Meteorological conditions associated with ozone episodes in the SJA are similar to those for episodes in the WQC ie. a high pressure system over the Atlantic Ocean and a low pressure inland to the northwest (see Figure 9).

Surface flow is generally from the southwest on the backside of the high pressure cell, up the seaboard of the United States (CCME 1989, Concord 1984).

Back trajectory analyses for sites in Atlantic Canada show that air masses usually pass over the Atlantic Ocean before reaching the area. The trajectory in Figure 23 for an ozone episode in Saint John, New Brunswick shows that air flows would have passed over the WQC as well as large emission source areas along the eastern seaboard in the U.S. before reaching Saint John, with part of the flow path over the ocean. Ozone concentrations tend to decrease slowly for transport over the ocean as deposition, NO_x scavenging, and dispersion all tend to be less important than for transport over land. When the air mass reaches the coast, it will likely experience mechanical mixing due to the abrupt change in surface roughness. Ozone aloft may be brought down to the surface, even at night. A number of nocturnal peaks in ozone concentration have been reported at southern New Brunswick stations (Concord 1984).

The observational evidence does not support the occurrence of significant urban plumes from the city of Saint John.

VOC/NO_x Observations

There is a very limited data base on ambient air NO_x and VOCs.

Modelling Results

These has been no ozone medelling work done for the SJA.

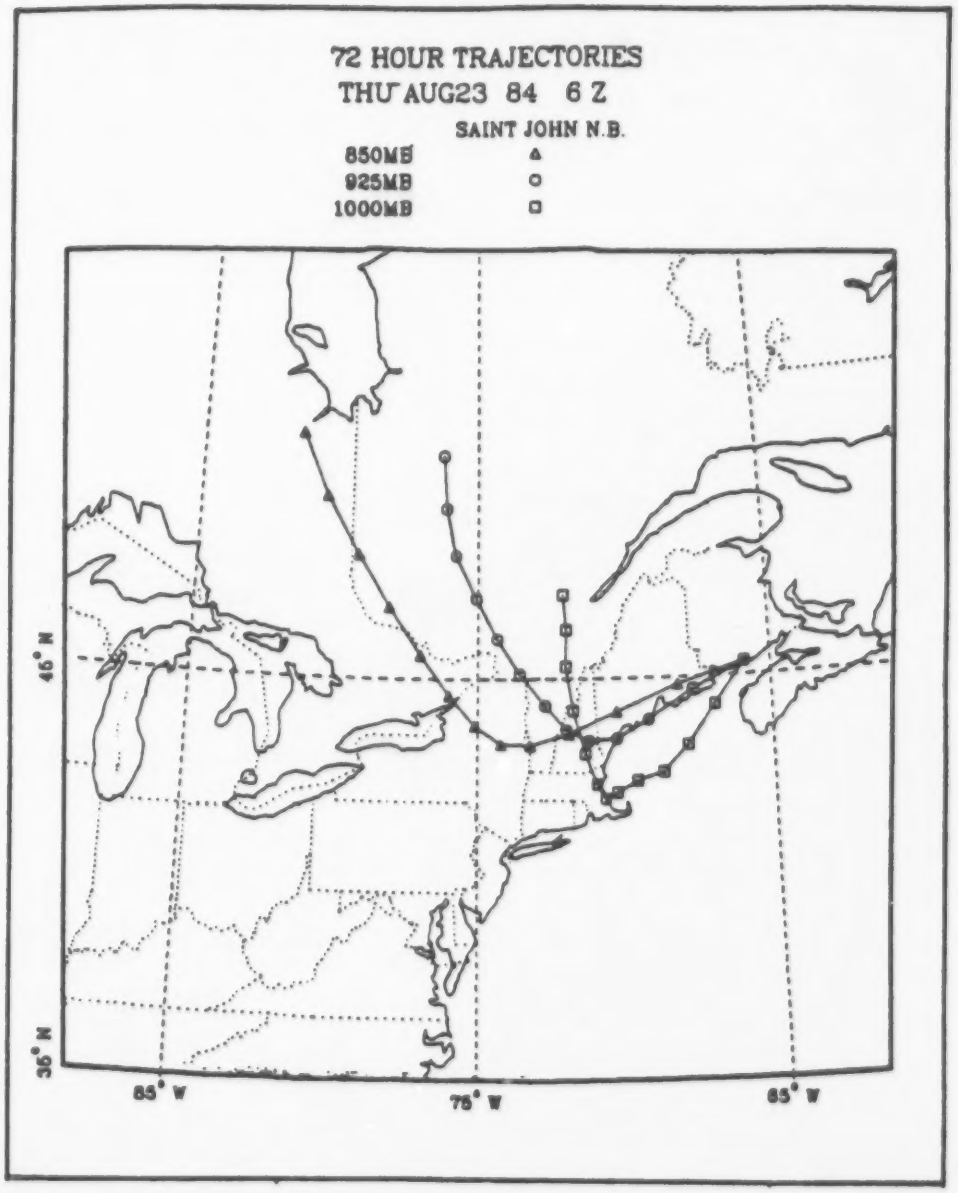


FIGURE 23 BACK TRAJECTORY FOR OZONE EPISODE IN SAINT JOHN, N.B.

Emissions

Emissions of NO_x and VOC in the SJA in 1985 and 2005 are estimated as follows:

	1985	2005	% Change
NO_x			
- mobile	5.8	5.5	- 5%
- stationary	7.7	22.3	+ 289%
Total	13.5	27.8	+ 206%
VOC			
- mobile	3.7	2.8	- 24%
- stationary	6.8	8.0	+ 18%
Total	10.5	10.8	+ 3%

The large percentage increase in NO_x emissions indicated by the numbers is misleading in that 1985 was an abnormally low NO_x emission year with low production from the major NO_x source, power generation. It is more representative to compare 2005 emissions to 1987 or 1988 when electric power production was back up to typical levels and NO_x emissions from stationary sources in the SJA were about 18 kt/yr. Based on these levels, the stationary source increase to 2005 would be only about 21%.

The five largest sources of NO_x and VOCs in the SJA in 2005 are estimated to be:

NO_x Source	NO_x (KT)	% of Total
Power Generation	15.7	56
Industrial Fuel Combustion	3.7	13
Industrial Processes	2.2	8
Heavy Duty Vehicles	2.2	8
Offroad Diesel	1.8	6
	25.6	92

VOC Source	VOC (KT)	% of Total
Solvents	2.6	24
Fuelwood Combustion	2.4	22
Industrial Processes	2.1	19
Light Duty Vehicles	1.5	14
Gasoline Distribution	0.7	7
	9.3	86

Required Emission Reductions

Because of the large influence of imported pollutants, NO_x and VOC reductions from sources in the SJA will have a limited effect on the magnitude or frequency of ozone peaks. There may be a small additive affect of locally generated ozone that can be reduced by reducing NO_x and VOC emissions within the SJA.

VI Elements of the Plan

VI.1 Summary of Elements

The NO_x and VOC control initiatives in the plan are summarized in Tables 11 and 12 respectively. Studies and investigations for a second edition of the plan are summarized in Table 13.

For ease of identification and cross referencing, initiatives have been categorized and numbered as follows:

a) NO_x and VOC Emission Control Initiatives

	NO_x Control	VOC Control
National energy conservation and product control initiatives.	N101 - N199	V101 - V199
National consumer choice and lifestyle initiatives.	N201 - N299	V201 - V299
National emission source control initiatives.	N301 - N399	V301 - V399
Regional energy conservation and product control initiatives.	N401 - N499	V401 - V499
Regional consumer choice and lifestyle initiatives.	N501 - N599	V501 - V599
Regional emission source control initiatives.	N601 - N699	V601 - V699

B) Studies and investigations for Second Edition of the Plan.

S101 - S199 Emission inventories and forecasts
S201 - S299 Ambient Air Quality and Modelling
S301 - S399 Technologies, Control Options and Costs
S401 - S499 U.S. Emission Control

In Tables 4 and 5, estimated emission reductions in each of the selected regions and nationally are totalled after each successive stage of control. Percentage total reduction below 1985 emissions is also listed at the end of each control stage.

Brief descriptions of each of the plan initiatives are contained in the next three subsections. Effectiveness in reducing ground-level ozone, a schedule and mechnisms for implementing the plan, jurisdictions responsible and costs are dealt with in subsequent sections.

DRAFT

Table 11 NO_x/VOC Management Plan - NO_x Control Initiatives

Initiative		NO_x Reduction in 2005 (KT) LFV	MOC	SJA	Other[1]	Total
a) National						
Energy Conservation & Product Control (N100 series)						
N101	Electric power utility demand side management (DSM) programs in place by 1993 and energy efficiency performance standards/guidelines for selected electrical equipment, appliances, motors and lighting in place by 1994 targeting a minimum reduction in NOx emissions of 10% in 2 000, 15% in 2 005.	0.2	0.0	2.3	36.3	38.8
N102	Energy efficiency performance standards and design guidance documents, and mandatory energy efficiency reporting in permit applications, for selected industrial sectors as specified in schedule A.	1.2	8.3	0.4	10.8	20.7
N103	Voluntary internal energy audits by industry in parallel with environmental audits by 1992.	[No estimate of NO_x reductions]				
N104	New energy efficiency performance standards for buildings by 1994.	0.2	1.6	<0.1	1.9	3.7
	Subtotal N100 Series	1.6	9.9	2.7	49.0	63.2
	% Difference from 1985	-18.2	-3.0	+85.9[2]	-2.1	-2.5
Consumer Choice and Lifestyle (N200 series)						
N201	Public education campaign to encourage energy conserving driving habits and alternative transportation modes.	[No estimate of NO_x reductions]				
N202	Public education campaign to encourage voluntary energy conserving habits, product choices and design innovations in homes and businesses.	[No estimate of NO_x reductions]				
	Subtotal N200 Series		--	---	---	---
	Accumulative Reduction	1.6	9.9	2.7	49.0	63.2
	Accumulative % Difference from 1985	-18.2	-3.0	+85.9[2]	-2.1	-2.5

Table 11 (Cont'd)

Initiative	NO_x Reduction in 2005 (KT) LFV	WQC	SJA	Other[1]	Total
Source Control Initiatives (N300 series)					
N301 New light duty vehicle (LDV) NO_x emission standard of 0.4 g/mi fully implemented no later than 1996.	4.4	29.9	0.3	29.4	64.0
N302 New heavy duty vehicle (HDV) NO_x emission standards of 5 g/BHP-hr effective in 1995 and 4 g/BHP-hr effective in 2000 (provided another major jurisdiction has imposed an equivalent or tighter standard by that date).	1.3	7.8	0.2	11.6	20.9
N303 NO_x emission standards for diesel engines used in construction no less stringent than 6g/BHP-hr effective in 1998 (provided another major jurisdiction has imposed an equivalent or tighter standard by that date).	0.4	3.5	<0.1	4.0	7.9
N304 Cap on NO_x emissions from Canadian rail transport systems at 115 Kt/Yr effective 1992.	[Reductions already in NO_x forecast]				
N305 New source performance standards for power plants to NO_x emission levels not less stringent than:	---	---	---	30.0	30.0
N306 New source performance standards, effective in 1994, for commercial/industrial boilers with >6 MJ/s heat input, to NO_x emission levels (as NO_2) no less stringent than:	1.6	16.5	0.4	17.4	35.9

N305 detail:

	Effective 1995	Effective 2 000
coal	170 ng/J	100 ng/J
oil	110 ng/J	90 ng/J
gas	50 ng/J	30 ng/J

N306 detail:

Coal	150 ng/J of heat input
Heavy oil	110 ng/J of heat input
Light oil	50 ng/J of heat input
Gas	30 ng/J of heat input

Table 11 (Cont'd)

Initiative		NO_x Reduction in 2005 (KT) LFV	WQC	SJA[2]	Other[1]	Total
N307	New source performance standards, effective in 1994, for stationary gas turbines to NO_x emission levels (as NO_2) not less stringent than: Turbines larger than 100 MMBTU/hr 25 ppmv Turbines in range 1-100 MMBTU/hr 42 ppmv	--	1.2	--	15.5	16.7
N308	National adoption of current Alberta NO_x standards for gas-fired reciprocating compressor engines, effective in 1993.	--	---	---	14.5	14.5
	Subtotal N300 Series	7.7	58.9	0.9	122.4	189.9
	Accumulative Reduction	9.3	68.8	3.6	171.4	253.1
	Accumulative % Difference from 1985	-26.5	-13.2	+79.3[2]	-12.2	-12.6

b) Regional

Energy Conservation & Product Control (N400 series)

N401	Urban transportation management plans designed to reduce NO_x emissions - all urban centres in LFV and WQC with populations greater than 200,000 by 1992.	[No estimate of NO_x reduction]

Consumer Choice and Lifestyle (N500 series)

N501	"Restricted activity day" programs in place in all urban centres in the LFV and WQC with populations greater than 500,000 by 1993.	[No estimate of NO_x reduction]
N502	More effective speed limit enforcement and/or lower speed limits to achieve no less than a 10 km/hr reduction in average speed of HDVs on major highways in summer - LFV and WQC by 1993.	0.7 4.4 --- --- 5.1
N503	Public education campaigns promoting the environmental benefits of reduced highway speeds in summer - LFV and WQC.	[No estimate of NO_x Reduction]
	Subtotal N500 Series	0.7 4.4 --- --- 5.1
	Accumulative Reduction	10.0 73.2 3.6 171.4 258.2
	Accumulative % Difference from 1985	-27.3 -14.0 +79.3[2] -12.2 -12.8

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Table 11 (Cont'd)

Initiative		LFV	WQC	SJA	Other[1]	Total
		NO_x Reduction in 2005 (KT)				
Source Control Initiatives (N600 series)						
N601	Light duty vehicle (LDV) inspection & maintenance programs (I&M) and anti-tampering legislation in the LFV and WQC by 1994.	0.7	4.4	---	---	5.1
N602	Region specific new source performance standards for the LFV and WQC effective in 1995, and retrofit existing fossil-fuelled power plants in the LFV and WQC by 1997 to NO_x emission levels no less stringent than: Coal 100 ng/J of heat input Oil 90 ng/J of heat input Gas 30 ng/J of heat input	0.8	57.2	---	---	58.0
N603	Retrofit 50% of existing commercial/industrial boilers by 1997 in the LFV and WQC to NO_x emission levels no less stringent than: Coal 150 ng/J of heat input Oil 110 ng/J of heat input Light oil 50 ng/J of heat input Gas 30 ng/J of heat input	0.3	2.8	---	---	3.1
N604	New source performance standards effective in 1995 and a retrofit program for completion by 1997, for NO_x process emissions from iron and steel mills in the WQC.	[No estimate of NO_x reduction]				
N605	Retrofit refineries in the LFV and WQC to control NO_x process emissions, by 1997.	[No estimate of NO_x reduction]				
	Subtotal N600 Series	1.8	64.4	---	---	66.2
	Total Reduction	11.8	137.6	3.6	171.4	324.4
	Total % Difference from 1985	-29.2	-25.3	+79.3[2]	-12.2	-16.4
	Total Emissions 1985	92.7	572.2	13.5	1208.5	1886.9
	2005 Pre Plan	77.4	565.2	27.2	1232.3	1902.7
	2005 Post Plan	65.6	427.6	24.2	1060.9	1578.3

Notes:

1 Other means rest of Canada

2 1985 was an abnormally low NOx emissions year in the SJA with NOx from power generation (the largest source) only about 30% of the level in 1988. Referencing the 1988 level would give a small reduction rather than the high percentage increase obtained by referencing 1985.

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Table 12 NO_x/VOC Management Plan - VOC Control Initiatives

Initiative		VOC Reduction in 2005 (KT) LFV	WQC	SJA	Other[1]	Total
a) National						
Energy Conservation & Product Control (V100 series)						
V101	Program to reduce the solvent content of paints, primers & thinners by 1995 as follows: - 50% of exterior oil-based paints to <0.25 kg/L solvent - 50% of primers to <0.25 kg/l solvent - 25% of thinners to <0.2 kg/l solvent	1.4	11.1	0.1	10.1	22.7
V102	Program to replace 75% of interior oil-base paints with water-base by 1995.	0.8	6.4	0.1	5.7	13.0
V103	Program to replace 25% of solvent base glues & adhesives with water-base or low solvent adhesives by 1997.	0.5	4.3	<0.1	4.0	8.8
V104	Summer ban on the sale and use of auto solvent-base windshield wash starting in 1991.	0.8	6.5	0.1	6.6	14.0
V105	Program to reduce the reactive VOC and solvent contents of consumer products: - 50% reduction in VOCs from automobile products by 1995 - Ban on reactive VOCs from propellants in household & personal use products by 1993. - 20% reduction in solvent content of household & personal use products by 1995.	0.7	5.6	0.1	5.8	12.2
V106	Ban on outdoor pesticide application in urban areas during ozone episodes. (No significant annual VOC reduction)	---	---	---	---	----

Table 12 (Cont'd)

Initiative		VOC Reduction in 2005 (KT) LFV	WQC	SJA	Other[1]	Total
V107	Multi-element program to reduce VOC emissions from miscellaneous industries and general solvent use by 20% by 2 000.	1.4	12.5	0.1	13.0	27.0
	Subtotal V100 Series	11.6	72.8	0.9	78.2	163.5
	% Difference from 1985	-15.0	+5.1	-4.8	+0.8	+1.6
Consumer Choice & Lifestyle (V200 series)						
V201	Public education campaign to encourage energy conserving driving habits and alternative transportation modes (same as N202)	[No estimate of VOC reduction]				
V202	Public education campaign on solvents to:	[No estimate of VOC reduction]				
	- encourage use of water base paints - encourage solvent recovery & recycle - discourage purchase of aerosol hairspray & underarm products - increase industry awareness of concerns, options					
	Subtotal V200 Series		---	---	---	---
	Accumulative Reduction	11.6	72.8	0.9	78.2	163.5
	Accumulative % Difference from 1985	-15.0	+5.1	-4.8	+0.8	+1.6
Source Control Initiatives (V300 Series)						
V301	New light duty vehicle (LDV) hydrocarbon emission standard of 0.25g/mi fully implemented no later than 1996.	1.2	7.7	0.1	7.3	16.3

Table 12 (Cont'd)

Initiative		VOC Reduction in 2005 (KT) LFV	WQC	SJA	Other[1]	Total
V302	Requirement that all new gasoline storage and transfer depots (bulk and marketing terminals) be equipped for vapour balancing or recovery, effective 1992.	0.4	3.9	<0.1	4.1	8.4
V303	Requirement for all new service station tanks in urban areas to have gasoline delivery vapour balancing equipment from 1992.	0.3	3.1	<0.1	3.3	6.7
V304	Requirement that all large new tanks storing volatile organic liquids be equipped with state-of-art vapour control by 1993.	1.3	10.6	0.6	3.9	16.4
V305	New source performance standard for process emissions from new organic chemical plants, effective 1994.	---	33.0	---	52.3	85.3
V306	New source performance standard for plastics processing, effective 1995.	[No estimate of VOC reduction]				

Table 12 (Cont'd)

Initiative		VOC Reduction in 2005 (KT) LFV	WQC	SJA	Other[1]	Total
V307	New source performance standard for sulphate process in pulp & paper plants, effective 1994.	[No estimate of VOC reduction]				
V308	New source performance standard for commercial/industrial paint application facilities, effective 1994.	1.5	12.1	0.1	11.0	24.7
V309	New source performance and operating standards for printing ink manufacturers, effective 1994.	[Included under V310]				
V310	New source performance standards for commercial/industrial printing facilities, effective 1994.	0.3	2.7	<0.1	2.9	5.9
V311	New source performance standard for commercial/industrial degreasing, effective 1995.	0.3	2.6	<0.1	2.8	5.7
V312	New source performance standard and manual on improved handling practices for dry cleaners, effective 1995.	0.2	0.6	<0.1	1.4	2.3
	Subtotal V300 Series	5.5	76.3	0.9	89.0	171.7
	Accumulative Reduction	17.1	149.1	1.8	167.2	335.2
	Accumulative % Difference from 1985	-19.8	-4.5	-21.0	-13.3	-7.6

b) Regional

Energy Conservation and Product Control (V400 series)

V401	Urban transportation management plans designed to reduce VOC emissions - all urban centres in LFV and WQC with populations greater than 200,000 by 1992. [Same as N401]	[No estimate of VOC reduction]

Consumer Choice and Lifestyle (V500 series)

V501	"Restricted activity day" programs in place in all urban centres in the LFV and WQC with populations greater than 500,000 by 1993. [Same as N501]	[No estimate of VOC reduction]

Table 12(Cont'd)

Initiative		VOC Reduction in 2005 (KT) LFV	WQC	SJA	Other[1]	Total	
Source Control Initiatives (V600 series)							
V601	Light duty vehicle (LDV) inspection and maintenance programs and anti-tampering legislation in the LFV and WQC by 1993 [same as Initiative N601]		4.3	26.4	---	---	30.7
V602	Reduction in gasoline RVP in 1992 in LFV, WQC, Nova Scotia and New Brunswick to:						
	9.0 psi June, July & August 10.5 psi May & September						
	- VOC reduction from motor vehicles	5.2	32.0	0.3	4.8	42.3	
	- VOC reduction from gasoline distribution	1.0	4.9	0.1	0.8	6.8	
V603	Requirement for vapour balancing and recovery at existing gasoline storage and transfer depots (bulk and marketing terminals) in the LFV and WQC by 1993.	1.0	9.0	---	---	10.0	
V604	Requirement for gasoline delivery vapour balancing at existing service stations in the LFV and WQC, effective 1993.	1.1	10.0	---	---	11.1	
V605	Requirement for vehicle refueling vapour balance at service stations in the LFV and WQC:						
	- new stations from January 1, 1993	0.6	5.7	---	---	6.3	
	- existing stations by December 31, 1995	1.4	13.3	---	---	14.7	
V606	Requirement that fugitive emission inventory and leak reduction programs be implemented at refineries in the LFV, WQC and SJA by 1993.	1.7	13.3	0.8	---	15.8	
V607	Retrofit of existing organic chemical plant processes in the LFV and WQC to NSPS by 1996.	0.2	54.5	---	---	54.7	
V608	Requirement that fugitive emission inventory and leak detection and repair programs be implemented at organic chemical plants in the LFV and WQC, & elsewhere near large urban centres by 1993.	<0.1	3.4	---	2.2	5.6	

Table 12 (Cont'd)

Initiative		VOC Reduction in 2005 (KT) LFV	WQC	SJA	Other[1]	Total
V609	Retrofit of major existing plastic processing plants in the LFV and WQC to NSPS by 1991.	(No estimate of VOC reduction)				
V610	Retrofit of existing sulphate processes in pulp & paper plants in the LFV, WQC and SJA to NSPS by 1997.	(No estimate of VOC reduction)				
V611	Retrofit existing ink manufacturing facilties in the LFV and WQC to NSPS by 1996.	0.4	3.7	---	---	4.1
V612	Retrofit existing rotogravure and flexography printers in the LFV and WQC to NSPS by 1996.	0.4	3.7	---	---	4.1
V613	Retrofit existing commercial/industrial degreasing operations in the LFV and WQC to NSPS by 1997.	0.2	1.3	---	----	1.5
V614	Retrofit existing dry cleaners in the LFV and WQC to NSPS by 1997.	0.4	1.5	---	---	1.9
V615	Retrofit improved emission controls for wood waste burning in the LFV by 1995, and ban the practice entirely during O_3 episodes beginning in 1991.	?	---	---	---	?
	Subtotal	17.9	182.7	1.2	7.8	209.6
	Total Reduction	35.0	331.8	3.0	175.0	544.8
	Total % Difference from 1985	-35.5	-27.5	-24.8	-9.6	-18.9
	Total Emissions 1985	114.1	794.8	10.5	934.1	1853.5
	2005 Pre Plan	108.6	908.4	10.9	1019.5	2047.4
	2005 Post Plan	73.6	576.6	7.8	844.6	1502.6

Note:
[1] Other means rest of Canada

Table 13 Studies and Investigations for Second Edition of the Plan

Study	Initiative	Agencies
Emission Inventories and Forecasts (S100 Series)		
S101	Streamline emission inventories with automated provincial reporting and maximum of 1 year lag time.	Env. Canada All provinces
S102	Update the national emission forecast annually, extending it to 2010.	Env. Canada All provinces
S103	Conduct emission surveys for the pulp and paper and wood transformation sectors.	Envi. Canada NB, Que, Ont, BC
S104	Develop a more accurate data base on emissions from products containing solvents (pesticides, general solvent use, etc.).	Env. Canada All provinces
S105	Determine the number and usage rates of off-road vehicles.	Env. Canada
S106	Prepare refined sets of inventory data for the WQC with aereal resolution to facilitate oxidants modelling.	Env. Canada Que, Ont
Ambient Air Quality and Modelling (S200 Series)		
S201	Analyze available ambient air monitoring data to obtain additional information on ozone episode characteristics.	Env. Canada NB, Ont, Que, BC
S202	Obtain better information on the transbondary flow of NO_x, VOCs and ozone and the penetration of these pollutants into various segments of the LFV, WQC and SJA.	Env. Canada NB, Ont, Que, BC
S203	Prepare refined meteorological data sets for the WQC with aereal resolution to facilitate oxidants modelling.	Env. Canada
S204	Set up and run appropriate scale oxidants models for the LFV and WQC, preferrably with grid sizes for episode modelling not greater than 20 km X 20 km for rural areas or 10 km X 10 km for urban areas.	Env. Canada Ont, Que, BC
Technologies, Control Options and Costs (S300 Series)		
S301	Refine the cost estimates for control of VOC emissions from major sources (organic chemical plants, etc.).	Env. Canada Ont, Alta
S302	Evaluate the type and extent of VOC emission controls currently employeed in the plastics, pulp and paper and wood transformation industries.	Env. Canada

Table 13 (continued)

Study Initiative		Agencies
S303	Conduct periodic reviews and joint government/ industry R&D on advanced combustion and NOx emission control technologies.	Env. Canada EMR
S304	Evaluate the extent of current control and product substitution in all major solvent use categories.	Env. Canada Ont, BC
S305	Evaluate the additional control and product substitution options available for major solvent use categories.	Env. Canada Ont, BC
S306	Evaluate measures planned or implemented under the greenhouse gas control program and their implications for NO_x and VOC emissions.	Env. Canada EMR, all provinces
S307	Analyze Canadian passenger & goods transport networks to determine potential for intermodal shifts on major arteries to reduce CO_2, NO_x and VOC's.	Trans. Canada EMR
U.S. Emission Control (S400 Series)		
S401	Analyze the new U.S. NO_x control program for NO_x reductions in selected regions (Ohio Valley, eastern seaboard, etc.) between now and 2010.	Ont, Que, BC Env. Canada
S402	Analyze measures in, and track implementation of, State Implementation Plans (SIPs) in selected ozone non-attainment areas in the U.S. (Michigan, Ohio, New York, etc.)	Ont, Que, BC Env. Canada
S403	Analyze any plans by Detroit to develop a stable methanol supply and opportunities to work jointly with Detroit in using this supply for penetration of methanol fuelled vehicles into southern Ontario.	Ont.

VI.3 Description of NO_x Control Initiatives

a) National

Energy Conservation and Product Control (N100 series)

Initiative N101

Electric power utility demand side management (DSM) programs in place by 1993 and energy efficiency performance standards/guidelines for selected electrical equipment, appliances, motors, and lighting in place by 1994 targeting a minimum reduction in NOx emissions of 10% by 2000 and 15% by 2005.

This initiative consists of an integrated package of demand side management programs and energy efficiency performance standards/guidelines.

- DSM refers to techniques for influencing the pattern and quantity of electricity demand by consumers. It includes such things as load shifting from peak to off-peak hours and utility stimulated energy conservation programs for residential, commercial and industrial consumers. Emission reductions are achieved by reducing the electricity generated at fossil-fuelled power plants, by shifting more of the generation to other generation means (nuclear, hydro) and/or reducing overall electricity demand on the system.

- Energy efficiency performance standards ensure that new or replacement electrical equipment, motors, appliances (white goods), and lighting are the best economically available technology.

In 1985, Power Generation accounted for 247.9 Kt (13%) of Canada's NO_x emissions. This is forecasted to grow to 351.7 Kt (18.5%) of Canada's NO_x emissions in 2005. There is potential for large emission reductions through a combination of national energy efficiency performance standards/guidelines

and utility stimulated energy conservation programs. Performance standards will ensure that new and replacement equipment is energy efficient while DSM programs will encourage electricity consumers to utilize energy efficient products and systems.

Electricity consumption in Canada is 27% by residential consumers, 24% by commercial consumers and 41% by industrial consumers (line losses account for the other 8%).

- Energy conservation measures that can be taken in the residential sector include programs to reducing space heating demands through insulation upgrades in homes and replacing heating systems with heat pumps, reducing hot water use through better technology and improved use habits, upgrading appliances to more energy efficient models and upgrading lighting to more energy efficient lighting technologies.

- In the commercial sector, energy efficiency improvements can be made through upgrading lighting, heating and cooling systems as well as motors and other equipment to more efficient technologies.

- Industrial sector energy efficiency improvements can be made through measures such as upgrade to high efficiency electric motors, switching to induction heating of metal, switching to infrared radiation heating for drying surface coatings and heating materials for processing, replacing fossil fuelled furnaces with electric induction furnaces, switching to microwave heating, and installation of systems to recover waste process heat such as heat pumps and mechanical vapour recompression (MVR) systems. Some of these "electrotechnologies" will increase electricity demand thereby decreasing emissions at industrial sites at the expense of increasing emissions from power plants. However, the significant energy efficiency gains achievable are such that in most cases both electricity demand and industry emissions would be reduced. Where some increase in electricity demand occurs, the emission source is switched from the industry to the power plant where emissions are concentrated and more readily controlled, or where non-fossil electricity generation may be available to supply the increased demand.

Target dates for energy performance standards under the plan are as follows:

	Equipment	Target Date
1.	White Goods (clothes washers, clothes dryers dishwashers, freezers, refrigerators, ranges)	1994
	* *it is assumed that Ontario Level Standards are adopted nationally by 1991*	
2.	Heating and Cooling Equipment	1994
3.	Lamps and Light Bulbs	1994
4.	Motors	1994

It is estimated that a combination of strong utility DSM programs and energy efficiency performance standards should be able to reduce electrical energy demand in 2005 by 20% of forecast levels. The recommended target NOx reductions in N102 of 10% by 2000 and 15% by 2005 for all utilities are considered reasonable, leaving room for uncertainties and different stages of current utility DSM programs.

Development of energy efficiency performance standards and an integrated DSM/Standards plan will be coordinated by the federal Department of Energy, Mines and Resources in cooperation with provincial energy departments, utilities and other stakeholders. The emission reduction goals outlined in N102 will be accomplished by formal submission by all provincial electric power utilties to provincial energy departments before December 31, 1993, of comprehensive DSM plans designed to achieve the 10% and 15% NOx reduction targets. This will be followed with annual reporting on program status and achievements.

Initiative N102

Energy efficiency performance standards and design guidance documents, and mandatory energy efficiency reporting in permit applications, for selected industrial sectors as specified in Schedule A.

Energy efficiency performance standards will define target levels for energy efficiency of various industrial processes and energy efficiency design guidance documents will increase awarness among both designers and regulators of opportunities to minimize energy consumption by industry. Both the performance standards and the guidance documents will provide readily available criteria against which environmental impact statements and construction and operating permits for new industrial plants can be evaluated. Formally requiring that industry define in permit applications the energy efficiency measures taken and how they conform with the performance standards and guidance documents is expected to stimulate industry attention to energy efficient plant design and operating practices.

Target dates for energy efficiency performance standards and design guidance documents under the plan are listed in Schedule A below.

Schedule A

	Industry	Target Date
1	Iron & Steel Mills	31 December, 1992
2	Plastic & Synthetic Resin Manufacture	"
3	Industrial Chemical Plants	"
4	Cement Manufacture	"
5	Concrete Products Manufacture	"
6	Pulp & Paper Mills	31 December, 1993
7	Petroleum Refineries	"
8	Motor Vehicle Manufacture	"
9	Motor Vehicle Parts Manufacture	"
10	Other Petroleum & Coal Products Manufacture	"
11	Other Chemical Manufacture	31 December, 1994
12	Metal Stamping and Pressing	"
13	Tire & Tube Manufacture	"
14	Synthetic Textile Mills	"
15	Vegetable Oil Mills	"
16	Stone Products Manufacture	31 December, 1995

Schedule A was developed with consideration of industry sector energy consumption, NO_x and VOC emissions, SO_2 and CO_2 emissions, general proximity of the industry or electrical energy source to ozone problem areas, and anticipated growth of the sector.

Development of the energy efficiency performance standards and guidance documents will be coordinated by the federal Department of Energy, Mines and Resources in cooperation with provincial energy departments, industry and other stakeholders. The performance standards and guidance documents will be issued concurrently. Provincial departments will require industry to describe energy efficiency measures encorporated in plant designs and operation in all EIS's and permit applications starting in 1991, linking these to the performance standards and guidance documents as they become available.

Initiative N103

Voluntary internal energy audits by industry in parallel with environmental audits by 1992.

Environmental audits within industry evaluating their performance against environmental standards and accepted good operating practices are an effective tool in promoting industry awareness within the industry itself of environmental shortcomings and opportunities, and bringing about environmental improvements. The same opportunities are there for energy efficiency and conservation.

Under this plan, all industrial sectors are requested to establish formal energy audit procedures within their companies, linking them to environmental performance.

Initiative N104

New energy efficiency performance standards for buildings by 1994.

There is real potential for energy efficiency improvements in new buildings. This requires updating of provincial building codes, preferrably in a consistent manner across the country.

Under the plan, the Energy, Mines and Resources Canada will organize a systematic update of the national building code requirements for both residential and commercial buildings, be completed by December 31, 1993. This will be done in cooperation with Cent- . Mortgage and Housing Corporation and provincial housing and energy departments, such that the revised requirements can be incorporated into provincial codes.

Consumer Choice and Lifestyle (N200 Series)

Initiative N201

Public education campaign to encourage energy conserving driving habits and alternative transportation modes.

This compaign should concentrate on the summer ozone season, explaining the concerns with ground-level ozone and the contribution of automobiles to the ozone problem. There are many messages that could be delivered such as the harm caused by the significantly higher emissions when driving above the speed limit, the opportunities for trip consolidation and reduced emissions that would result, the need to minimize automobile use during peak ozone episodes and the environmental advantages of public transit.

Initiative N202

Public education campaign to encourage voluntary energy conserving habits, product choices and design innovations in homes and businesses.

There are many topics that could be dealt with in this campaign. Examples include promoting purchase of energy conserving lighting equipment and appliances, promoting heating equipment and insulation upgrading, and presenting examples of energy conserving practices and habits in homes and businesses. All messages should be linked not just to energy conservation per se but to the environmental advantages of conserving energy.

Source Control Initiatives (N300 Series)

Initiative M301

New light duty vehicle (LDV) NO_x emission standard of 0.4 g/mi fully implemented no later than 1996.

The current NO_x emission standard for LDVs of 1.0 g/mi, which become effective in 1987, will result in a reduction in LDV emissions to half their current rate by year 2000, after which a gradual increase in emissions will take place through to year 2005 and beyond. Despite the substantial reduction in NO_x emissions, LDVs will still be the single largest source of NO_x in urban centres in year 2005.

A 0.4 g/mi limit is currently being phased-in in California, and according to the proposed Clean Air Act amendments in the United States will be phased in nationwide over the 1993-95 period. Some vehicles have been certified below the 0.4 g/mi limit. However, the combination of a 0.4 g/mi NOx and a 0.25 g/mi hydrocarbon standard is to some degree technology forcing. The concern is with ensuring continuing compliance by vehicles in-use.

The new Canadian standard of 0.4 g/mi will be established for passenger cars before December 31, 1991 and for light duty trucks by December 31, 1992, through amendment to the current regulation under the federal Motor Vehicle Safety Act administered by Transport Canada.

Initiative M302

New heavy duty vehicle (HDV) NO_x emission standards of 5 g/BHP-hr effective in 1995 and 4 g/BHP-hr effective in 2000 (provided another major jurisdiction has imposed an equivalent or tighter standard by that date).

The current Canadian NO_x limit for HDVs is 6 g/BHP-hr. However, it is expected that all HDV engines sold in Canada will meet a 5 g/BHP-hr after 1991, when that control level comes into effect in the United States. This assumption has in fact been made in the base emission forecast (NO_x/VOC Emission Forecast 90-A) used in developing the plan.

Even with all new HDVs meeting 5 g/BHP-hr, NO_x emissions from HDVs in 2005 will be only slightly below the current level. Introducing a Canadian standard of 0.4 g/BHP-hr in 2000 will cause an additional modest reduction by 2005. It will still leave HDV NO_x emissions second only to NOx from off-road diesel nationally when all plan initiatives have been implemented. In the WQC, HDVs will be far and away the largest source sector for NO_x in 2005 after the plan has been implemented.

The new NO_x standards for HDVs will be established before December 31, 1992 by amending the current regulations under the federal Motor Vehicle Safety Act administered by Transport Canada.

Initiative M303

NO_x emission standards for diesel engines used in construction no less stringent than 6 g/BHP-hr effective in 1998 (provided another major jurisdiction has imposed an equivalent or tighter standard by that date).

Offroad diesel engines (mobile and stationary) are projected to be the second largest source of NO_x emissions nationally in 2005 without implementing the plan, and the largest source sector after implementing the plan. Fortunately, a significant percentage of offroad diesel engine emissions are not located in urban population centres (eg. engines used in forestry, mining, agriculture, etc.). An exception is diesel engines used in construction. A significant percentage of construction activity is located in or near urban centres, and specifically within identified ozone problem areas. The rapid population growth in the greater Vancouver area, and industrial growth in the Windsor-Quebec corridor have resulted in intensive construction activity. The Darlington nuclear station, for example, just downwind of Toronto and in an area of frequent high peak ozone episodes, is presently the largest single construction project in North America.

The authority to regulate offroad diesel engines is included in the proposed amendments to the U.S. Clean Air Act. It is likely that regulatory measures will follow in the not too distant future.

The California Air Resources Board has examined the feasibility of controlling NO_x emissions from offroad, heavy duty construction equipment (XX). They identified three possible levels of control:

Level I	10.0	g/BHP-hr HC + NO_x
Level II	1.07	g/BHP-hr HC
	5.7	g/BHP-hr NO_x
Level III	1.07	g/BHP-hr HC
	4.5	g/BHP-hr NO_x

The 6.0 g/BHP-hr level defined in Initiative N303 is roughly equivalent to the California Level II. It represents about a 40% NO_x reduction from uncontrolled emission levels for many models of engines, which emit NO_x in the 10 g/BHP-hr range at optimum performance and fuel economy.

It is assumed that the emission limit would be set under federal statute (Motor Vehicle Safety Act or Canadian Environmental Protection Act, amended if necessary) before December 31, 1995. The limit and date of application would depend on control measures of equal or greater stringency being in place in another major jurisdiction (California, United States, European countries competing in the diesel engine market, etc.).

Initiative N304

Cap on NO_x emission from Canadian rail transport systems at 115 Kt/Yr effective 1992.

The NO_x emissions projections now included in the reference emission forecast for the plan (NO_x/VOC Emission Forecast 90-A) are based upon Railway Association of Canada development of traffic and fuel efficiency history and forecasts. Factored into the assumptions used are diesel locomotive replacements at a rate of 40 locomotives per year ($80,000,000 capital cost) in 1995 and beyond and the expectation that new engines will emit 10% less NO_x than those currently in use.

This latter assumption is a component of a projected 14% decrease in NO_x from locomotives between 1985 and 2005. Principally, railway "system" improvements in productivity have reduced fuel consumption and are expected

to continue to reduce fuel consumption and hence emissions per tonne-mile. Combined with predicted railway traffic growth and operational changes, a 14% decrease in NO_x is forecast. This supersedes a 26% increase estimated previously by CCME assuming "status quo" in terms of operational practices and engine performance.

Given the current unavailability and uncertain future timing of "engine technology" improvements in NO_x, the 14% emission reduction forecast represents a cost-effective current estimate of what can be achieved over the 1985 to 2005 time period.

It is anticipated that long term development programs undertaken by the locomotive engine manufacturers (U.S. based) will ultimately result in commercial production of improved new locomotives for the replacement programs of the railways. Adoption of recognized commercially available, high fuel efficiency/low NO_x new locomotives will be required as existing locomotives are progressively replaced by new units. The ongoing locomotive fleet replacement programs of the railways inevitably involve locomotives in all regions of Canada. The LFV and WQC regions will benefit from the flexible railway locomotive operating management strategies which maximize utilization and hence minimize fuel consumption and emissions.

Monitoring of compliance of the railway carriers and the locomotive manufacturing industry with the above initiatives will be undertaken by Federal authorities, given the national nature of the major railways and the very wide range of usage of the locomotive fleet. Transport Canada and Environment Canada, in consultation with the railways and other interested stakeholders, will establish reporting requirements by December 31, 1991.

Initiative M305

New source performance standards for power plants to NOx emission levels (as ng of NO_2 per joule of heat input) not less stringent than:

	Effective 1995	Effective 2000
Coal	150 ng/J	100 ng/J
Oil	110 ng/J	90 ng/J
Gas	50 ng/J	30 ng/J

Most of the new fossil-fuelled generating capacity between now and 2005 is expected to be in Alberta, Saskatchewan and the Atlantic provinces, with possibly some additional capacity in British Columbia. Also most of the new capacity is expected to be coal-fuelled with some support from gas turbine generation in Alberta.

Without implementing tighter NO_x control, power generation will be the largest source sector for NO_x nationally by 2005. Power generation emissions will be well above the next largest source category (off-road diesel engines), despite the assumption that there will be no new fossil generating capacity in Ontario and Quebec.

Much of the projected growth will not likely be in areas of most concern with respect to ground-level ozone. However, the growth in emissions without tighter control would be over 40% nationally by 2005, and considerably higher than 40% in some of the provinces installing new capacity. It is prudent to take preventative action to slow the rate of growth in emissions and minimize air quality degradation to the extent that technology will allow.

The current national emission guideline limits for NO_x emissions from coal, oil and gas-fuelled utility boilers are 258, 129 and 86 ng/J (ng of NO_2 per joule of heat input) respectively. These limits were based on technologies available in the 1970s.

The Control Technologies Work Group concluded that levels of 100, 90 and 30 ng/J are now achievable without resorting to expensive flue gas cleanup technology such as selective catalytic reduction. Less expensive combustion modification technologies such as flue gas recirculation and fuel re-burning appear to be able to achieve these levels, although some full scale demonstration work is still required. Initiative N303 calls for an interim

limit in 1995 to allow some flexibility and account for long lead times for power station planning, approval and development. This approach is considered to be reasonable, providing significantly reduced emissions from 1995 onward and hopefully stimulating more rapid development of higher efficiency low emission combustion tehcnologies such as Integrated Gasification Combined Cycle (IGCC) as perferred options to meet the tighter limit in year 2000.

The emission limit numbers in Initiative N303 are considered upper bounds for negotiating actual guideline numbers for 1995 and 2000 through a consultative process. The actual new limits, which could be lower than the upper bound numbers in N303, will be established by modifying the current thermal power emission guidelines under the Canadian Environmental Protection Act. Environment Canada will coordinate the guideline amendment process involving provinces, industry and other stakeholders, with a target date for completion of December 31, 1992. The guideline limits, or more stringent control if chosen by the provinces, will be implemented through provincial regulatory and/or permiting processes.

Initiative N306

New source performance standards, effective in 1994, for commercial/industrial boilers with >6 MJ/s of heat input, to NO_X emission levels (as NO_2) not less stringent than:

Coal	*150 ng/J of heat input*
Heavy Oil	*110 ng/J of heat input*
Light Oil	*50 ng/J of heat input*
Gas	*30 ng/J of heat input*

Although NO_X emissions from commercial/industrial boilers are presently only about half of NO_X emissions from power generation, they too are projected to grow substantially (by about 50%) by year 2000. The major difference with commercial/industrial boilers is that a higher percentage of the growth will occur in areas where ground-level ozone problems are most severe.

Initiative N303 calls for national new source performance standards for 1995 that are similar to the 1995 limits for power plants. The exceptions are the addition of a limit to cover the smaller commercial/industrial boilers that burn light fuel oil, and a lower limit for natural gas-fuelled boilers, which appears to be achievable on the gas-fuelled packaged boiler systems. Initiative N303 does not call for tighter limits in year 2000, mainly because of the greater variability in boiler types and sizes in the commercial/industrial boiler population, and the relativelly small percentage that are fuelled with coal.

The technologies available to control NO_x emissions from commercial/industrial boilers are similar to those for the larger utility boilers.

As with power plants, the emission limits in N304 are considered upper bounds with actual limits for 1994 to be established through a consultative process involving the various stakeholders. This effort will be coordinated by Environment Canada, with the product being a CCME national guideline that provinces will implement through provincial regulatory and permitting processes. The target date for the national guideline is December 31, 1991.

Initiative N307

New source performance standards, effective in 1994, for stationary gas-fired turbines to NO_x emission levels (as NO_2) not less stringent than:

For turbines larger than 100 MM BTU/hr heat input	*25 ppmv.*
For turbines in range 1-100 MM BTU/hr heat input	*42 ppmv.*

It is not known precisely what percentage of industrial fuel combustion NO_x emissions nationally comes from gas or oil-fired combustion turbines. It is estimated that, including turbines used in the natural gas industry itself, they emit about 28 Kt of NO_x annually, which is about 20 % of the NO_x emitted from commercial/industrial boilers. However, their use will continue to grow. Large gas turbines are looked upon as an option to help meet future electricity demands.

The emission limits in Initiative N305 are the minimum control levels adopted by the Northeast States for Coordinated Air Use Management (NESCAUM). If selective catalytic reduction (SCR) clean-up technology is used, much lower (8 ppmv) emission levels can be achieved for turbines larger than 100 MM BTU/hr heat imput (XX).

As with utility and industrial boilers, the actual emission limits for 1994 will be established through a consultative process involving all stakeholders and could result in emission limits lower than the upper bound numbers specified in Initiative N305. The limits will be contained in a CCME national guideline that will be implemented by provinces through provincial regulatory and permitting processes Environment Canada will coordinate the guideline development, with June 30, 1992 as the target date for completion.

Initiative N308

National adoption of the current Alberta NO_x emission standards for gas-fired reciprocating compressor engines, effective in 1993.

Gas-fired reciprocating compressor engines emit as much NO_x nationwide as all other forms of commercial/industrial fuel combustion combined. However these emissions are almost entirely in the three most westerly provinces, with more than 80% in Alberta. There are some reciprocating compressor engines used for gas distribution in Manitoba, Ontario and Quebec but total emissions are insignificant.

Alberta has recently established NO_x emission standards for new gas-fired compressor engines. It is estimated that by 2005 the new standards will have reduced compressor engine NO_x emissions in Alberta by about 40% from the 1985 emission level. Initiative N306 calls for a review of the Alberta standards and if found appropriate, adoption as national CCME guidelines. The conversion of the Alberta standards will be a joint effort by British Columbia, Alberta and Saskatchewan under Alberta coordination. The target date for completion of the CCME guideline is December 31, 1991.

b) Regional

Energy Conservation and Product Control (N400 Series)

Initiative N401

Urban transportation management plans designed to reduce NO_x emissions - all urban centres in LFV and WQC with population greater than 200,000 by 1992.

It is expected that substantial NO_x and VOC emission reductions can be achieved by improving the people and goods transportation efficiency within urban areas.

All urban centres in the Lower Fraser Valley and Windsor-Quebec city corridor with population greater than 200,000 will develop management plans by June 30, 1992 to ensure optimum efficiency of transportation in their area.

The provincial government will coordinate the development of these plans and provide the necessary incentives to ensure their implementation. One of the tasks associated with the coordination of these plans will be to estimate the emission reductions achieved.

Consumer Choice and Lifestyle (N500 Series)

Initiative N501

"Restricted activity day" programs in place in all urban centres with population greater than 500,000 by 1993 in the LFV and WQC.

It is reasonable to assume that NO_x and VOC emissions reach a maximum on hot summer days. These conditions are also conducive to high ozone levels when other meteorogical conditions are appropriate.

Certain activities could be reduced on the days for which an ozone episode is forecasted. The actions to be taken can be grouped in three categories depending on the potential severity of the forecasted episode.

Actions taken during Category I episodes can be mostly voluntary. They aim at preventing ozone concentrations from reaching high levels which could be harmful to the public in the short term. Examples of these actions include notification of the public through mass media to request its participation in abatement action, the banning of organic solvent use and the provision of free bus ride.

Category II and III measures would be specific mandatory actions which apply over Category I measures such as staggered or noon time start of work day, desincentives for private vehicles in downtown area, prohibition of single occupant vehicles from entering the freeway system and periodic power interuptions in residential areas.

The provinces of Quebec, Ontario and British Columbia will develop, in co-operation with the impacted industries and cities, ozone precursor curtailment plans for application during forecasted ozone episodes by March 31, 1993. These plans will include a series of voluntary and mandatory measures to be applied, the conditions which will trigger the implementation of the plan (or parts of it) and the emission reductions likely to be achieved. They will become effective for the summer of 1993.

Initiative N502

More effective speed limit enforcement and/or lower speed limits to achieve no less than to 10 km/hr reduction in average speed of heavy duty vehicles on major highways in summer by 1993 - LPV, WQC.

The amount of NO_x emitted by heavy duty vehicles increases rapidly as speed increases. It is also a known fact that many of these vehicles exceed the speed limits on highways.

More enforcement of speed limits and/or a reduction of the maximum speed limit would lead to a reduction in NO_x emissions. VOC emissions would be reduced as well but to a lesser extent.

Preliminary estimates indicate that a 10 km/hr reduction in average speed of heavy duty vehicles on highways would lead to a 10% reduction of NO_x emissions from these vehicles. (A 10% reduction for 45% of HDVs has been assumed in the current emissions reduction estimates)

The provinces of British Columbia, Ontario and Quebec will develop their own strategy to accomplish these reductions by December 31, 1992.

Initiative N503

Public education campaigns promoting the environmental benefits of reduced highway speeds in summer by 1993 - LFV and WQC.

NO_x and VOC emissions from light duty vehicles increase with speed. It is a well known fact that most vehicles exceed the current speed limits on highways especially during the summer.

It is estimated that a 10 km/hr reduction in average speed of light duty vehicles on major highways during the summer could lead to a ___% reduction of total NO_x emissions.

The provinces of British Columbia, Ontario and Quebec will develop a public education campaign promoting the environmental benefits of reduced highway speed in the summer by December 31, 1992.

Source Control Initiatives (N600 Series)

Initiative N601

Light duty vehicle (LDV) inspection and maintenance programs and anti-tampering legislation in the LFV and WQC by 1994.

Motor vehicle inspection and maintenance (I&M) programs usually consists of a regularly scheduled inspection of vehicles in a designated area to detect those vehicles emitting pollutants at rates greater than selected specifications or with inoperative or missing pollution control equipment. The owners of vehicles which fail an inspection are required to have them repaired before the vehicles can be relicenced. A compulsory inspection encourages owners not only to have their vehicles maintained in accord with a manufacturer's schedule but to avoid tampering and misfuelling.

Compulsory inspection and maintenance programs for light duty vehicles have been in operation in certain areas of the USA since 1974. At present there are programs in over 50 urban areas in 31 states. Agencies considering the implementation of I&M in Canadian urban areas have a considerable data base of information to consult when researching possible program types for their area. The GVRD has already examined I&M program options and chosen a centralized contractor-operated program (GVRD 1989).

Motor vehicle I&M will reduce VOCs more than NO_x. It is estimated that I&M will reduce NO_x emissions by about 4% and VOC emissions by about 16%. These are conservative estimates, particularly for VOCs, where the 16% estimate is scaled down from higher California estimates to account for higher average annual tailpipe emissions (in relation to evaporative emissions) in the colder Canadian climate. Comparable VOC reductions (30% range) may be achieved in Canada in warm summer months when ozone episodes occur.

Motor vehicle I&M programs in the LFV and WQC will be developed and implemented by British Columbia, Ontario and Quebec using provincial or regional regulatory authorities. These programs will be inplace by December 31, 1993.

Initiative N602

Region specific new source performance standards for the LFV and WQC, to be effective by 1995, and retrofit existing fossil-fuelled power plants in the LFV and WQC by 1997, to NO_x emission levels no less stringent than:

Coal	*100 ng/J of heat input*
Oil	*90 ng/J of heat input*
Gas	*30 ng/J of heat input*

Without an aggressive retrofit program, fossil-fuelled power generation NO_x emissions in 2005 will equal those from heavy duty vehicles (HDVs), with the two sectors representing the largest NO_x sources in the WQC in 2005. While the HDV emissions are spread along the corridor, the power plant emission sources are for the most part at the upwind end (with respect to typical ozone episode weather patterns). In addition, the largest single power plant source of NO_x, the Nanticoke generating station, is located in the middle of the area having the greatest number of hours of exceedance of the maximum acceptable ozone objective in Canada; the Lakeview generating station is located within the Toronto urban area where other major sources of NO_x and large VOC sources occur; the Lambton generating station is at the absolute upward end of the corridor adjacent to large refinery and petrochemical industry VOC sources; and the Lennox generating station is in the middle of the down wind ozone plumes from upwind Ontario and U.S. pollution sources. The Tracy oil-fired generating station just downwind of Montreal is also in the middle of a major urban plume, but represents only about 6% of the fossil-fuel generating capacity in the Ontario part of the corridor and is not a major concern. In the LFV, the gas-fired Burrard generating station is located at the head of Burrard Inlet where peak ozone levels occur.

The most effective available NO_x control retrofit technology is selective catalytic reduction, which can achieve NO_x emission levels well within the maximum levels specified in Initiative N604. The levels specified leave some flexibility in technology selection while still achieving significant emission reductions. Actual emission limits within the upper bound numbers in Initiative N604 will be determined by the Ontario and British Columbia governments by December 31, 1992 for both 1995 new source performance standards and 1997 existing plant retrofits.

Initiative N603

Retrofit 50% of existing commercial/industrial boilers by 1997 in the LPV and WQC to NO_x emission levels no less stringent than:

Coal	*150 ng/J of heat input*
Heavy oil	*110 ng/J of heat input*
Light oil	*50 ng/J of heat input*
Gas	*30 ng/J of heat input*

National new source performance standards for commercial/ industrial boilers will bring about significant NO_x emissions from this category, due to the lower emissions from the new (or modified) boilers and the penetration of new boilers into the existing boiler population. However, in ozone problem areas, emissions should be further reduced from at least the larger existing commercial/ industrial boilers as they will continue to represent a major NO_x source, often in close proximity to other significant NO_x sources and major VOC source areas.

The retrofit program in Initiative N605 will focus on the larger, newer boilers which are not likely to be retired in the next 10-15 years, but currently have little or no NO_x control. The provinces of B.C., Ontario and Quebec will undertake to identify the candidate retrofit boilers and establish, by December 31, 1993, retrofit limits (at or below the levels listed), retrofit plans and schedules to ensure effective NO_x reductions from the existing commercial/industrial boiler population by 1997.

Initiative N604

New source performance standards effective in 1995 and a retrofit program for completion by 1997, for NO_x process emissions from iron and steel mills in the WQC.

Iron and steel mills in Ontario are for the most part located in the heart of the WQC where ozone problems are most severe. The NO_x emissions from fuel combustion at iron and steel mills is dealt with by the industrial boiler emission control initiatives (N304 and N605). Initiative N606 deals only with emissions deriving from iron and steel mill processes.

Sintering and coking are the primary sources of process NO_x emissions at iron and steel mills. Smaller process sources include blast furnaces, rolling mills and fluonitric pickling operations.

NO_x emissions can be controlled by fuel combustion improvements and installation of flue gas emission and control equipment (such as selective catalytic reduction).

Appropriate new source and retrofit emission limits will be established by Ontario for iron and steel process by December 31, 1993. The new source standards take advantage of opportunities to reduce NOx when plant modifications or process changes are being made at existing mills. The retrofit schedule will call for full implementation of the program by December 31, 1997.

Initiative N605

Retrofit refineries in the LFV and WQC to control NO_x process emissions, by 1997.

Refineries in both the LFV and the WQC are in the heart of the ozone problem areas. (The refinery in Saint John is as well and consideration might also be given to retrofitting there). As with iron and steel mills refinery combustion emissions are dealt with under the boiler emission control initiatives (N304 and N605). Initiative N607 deals only with refinery process emissions, which contribute about 22% of the total NO_x emitted from refineries.

The catalytic cracking units in refineries are the primary non-combustion source of NO_x. British Columbia, Ontario and Quebec will work jointly to establish common new source and retrofit standards and criteria that could also he used in other jurisdictions. These will be in the form of a CCME guidelines to be completed by December 31, 1993. Each jurisdiction will set its own retrofit implementation schedule and reporting requirements.

VI.3 Description of VOC Control Initiatives

(a) National

Energy Conservation and Product Control (V100 Series)

Initiative V101

Program to reduce the solvent content of paints, primers and thinners by 1995 as follows:

- *50% of exterior oil-based paints to <0.25 kg/l solvent*
- *50% of primers to <0.2 kg/l solvent*
- *25% of thinners to <0.2 kg/l solvent.*

Solvent use is by far the largest VOC source category. Without the plan, solvent use VOC emissions are projected to represent 30% of all VOC emissions nationally by 2005, being 60% higher than industrial process emissions and 88% higher than motor vehicle emissions.

Among the many solvent use categories, the application of paints and coatings is the largest. VOC emissions from paints and coatings alone will contribute 40% of all solvent-related VOCs by 2005, and be more than 75% as high as motor vehicle emissions. California data suggests that the average solvent content of paints and primers is 0.67 kg/l, but that paints and primers with solvent contents as low as 0.25 kg/l are currently available. The South Coast Air Management District in California has also set a long-term objective of 0.2 kg/l for solvent content of thinners.

The foregoing is the basis for the solvent content targets in Initiative V102. They are considered only as indicative target reduction levels at this point, subject to further investigation and refinement. Environment Canada will coordinate a task force with provinces, paint manufacturers and other

stakeholders to further examine product reformulation opportunities and to establish solvent content targets for 1995 and 2000. These would be contained in a CCME guideline for which voluntary industry compliance and reporting will be sought. The guideline will be written in a form that it could readily be converted to a product standard by an appropriate standard setting body, or a VOC emission regulation under the Canadian Environmental Protection Act. The target date for completion of the guideline is December 31, 1992.

Initiative V102

Program to replace 75% of interior oil-base paints with water-base by 1997.

As indicated in Initiative V101, this measure is in fact a target subject to investigation and refinement. This initiative will involve development of a plan, by December 31, 1992, defining measures that will be taken between 1992 and 1997 to ensure that the 75% replacement objective is met.

Development of the plan will be coordinated by Environment Canada and involves a consultative process with paint manufactures, commercial painters, standard setting organizations and other stakeholders. The plan may include both voluntary and regulatory measures as deemed appropriate.

Initiative V103

Program to replace 25% of solvent base glues and adhesives with water-base or low solvent adhesives by 1997.

This initiative will have the same target dates and a similar process to Initiative V102, but with a different group of stakeholders as required. It will also be coordinated by Environment Canada. A plan to meets the above objective will be developped by December 31, 1993.

Initiative V104

Summer ban on the sale and use of solvent base auto windshield wash starting in 1991.

This will involve a formal request from CCME to windshield wash manufacturers and retailers to voluntarily curtail sales of solvent base windshield wash in summer. It will be supported by an information notice to consumers describing the request and reasons for it, and noting the agreement by industry to comply voluntarily. Environment Canada will send the request to manufacturers and retailers by March 31, 1991. A notice to consumers will be sent by April, 1991.

Initiative V105

Program to reduce the reactive VOC and solvent contents of consumer products:

- *50% reduction in VOCs from automobile products by 1995*
- *Ban on reactive VOCs from propellants in household & personal use products by 1993.*
- *20% reduction in solvent content of household & personal use products by 1995.*

This initiative involves separate actions for the two product categories: automobile care and maintenance products and household and personal use products. The consultative process for each would involve different industry stakeholder groups.

For each product type, an action plan will be developed by December 31, 1992 defining the specific measures that will be taken to meet the VOC and solvent reduction objectives. These may include regulatory measures, voluntary measures, economic incentives or other measures. Development of the plans will be coordinated by Environment Canada.

Initiative V106

Ban on outdoor pesticide application in urban areas during ozone episodes.

High rates of evaporative loss from application of solvent based pesticides during hot summer days can only add to oxidant formation. This initiative will be implemented through municipal bylaws targeting commercial pesticide companies, municipalities and public utilities (right-of-ways, parks, etc.), and individuals. A request will be made by CCME to municipalities to put appropriate municipal by laws in place by December 31, 1992.

Initiative V107

Multi-element program to reduce VOC emissions from miscellaneous industries and general solvent use by 20% by 2000.

This initiative involves development of an action plan by December 31, 1994 after further investigative studies have been completed on solvent users and opportunities to control emissions and reformulate products. Development of the plan will begin in 1993 under Environment canada coordination, and will involve a consultative process with solvent manufacturers, solvent users and other stakeholders. The plan will define specific measures and time frames as well as the mechanisms and jurisdictions for implementing the plan.

Consumer Choice and Lifestyle (V200 Series)

Initiative V201

Public education campaign to encourage energy conserving driving habits and alternative transportation modes.

[See description for Initiative N202]

Initiative V202

Public education campaign on solvents to:

- *encourage use of water base paints*
- *encourage solvent recovery & recycle*
- *discourage purchase of aerosol hairspray & underarm products*
- *increase industry awareness of concerns, options.*

A series of media information materials will be developed each focussing on a particular topic area with which consumers can readily identify. Each will convey messages of environmental preservation and health protection (eg. ground-level ozone, indoor VOCs, etc.)

Also information transfer materials will be developed to increase commercial/industrial user awareness of concerns and options available for such things as solvent recovery and recycle.

This program will be coordinated through the NO_X/VOC consultation office.

Source Control Initiatives (V300 Series)

Initiative V301

New light duty vehicle hydrocarbon emission standard of 0.25 g/mi for fully implemented no later than 1996.

The current Canadian hydrocarbon emission standard for light duty motor vehicles is 0.41 g/mi. Technology to reach 0.25 g/mi tailpipe is readily available and demonstrated. This limit is expected to be adopted nationwide in the U.S. by 1994 for at least part of the vehicle fleet.

The new standard will be established through amendment to the existing emission regulation under the Motor Vehicle Safety Act administered by Transport Canada. (Timeframe the same as N301)

Initiative V302

Requirement that all new gasoline storage and transfer depots (bulk and marketing terminals) be equipped for vapour balancing or recovery, effective 1992.

This measure implies that bulk terminals built after 1991 be equipped with systems allowing the transfer of vapour from the trucks to the storage tanks during delivery truck loading and from the storage tank to the trucks during tank loading. Marketing terminals built after 1991 will also be equipped with vapour recovery systems. Storage tanks built after 1992 and not hooked up to vapour recovery systems will have to be equipped with floating roofs (with primary and secondary seals) or any other equipment of equivalent efficiency.

These measures have a high cost effectiveness; when the gasoline throughout is sufficient, costs are rapidly recovered. They are necessary in order to put in place the rest of the Stage I controls (vapour balancing during service station delivery-Initiative V303). Similar measures are already in place in some U.S. States. Maximum throughput for the application of these measures will be determined in order to maintain their high cost effectiveness.

The code of practice being developed for Stage 1 control (Initiative V303) will contain all the specifies for vapour balance and recovery equipment. Guidelines on floating roof tanks will be developed through CCME under the coordination of Environment Canada (Initiative V304).

Initiative V303

Requirement for all new service stations tanks in urban areas to have gasoline delivery vapour balancing equipment from 1992.

This measure implies that all new service station tanks installed after 1991 be equipped with the appropriate piping to allow the vapours to be transferred from the tanks to delivery trucks during gasoline delivery. Vapour balance will take place at service stations supplied by terminals equipped to do the vapour balancing or processing.

It also implies that delivery trucks be made leak free so the vapours be transported to vapour processing units. A certification program will probably be required.

This control technique has been in use in some parts of the U.S.A. for 15 years and more. The adaptation of the equipment to colder climate is an aspect to be studied.

A code of practice is currently being developed through the Canadian Council of Minister of Environment (CCME). Environment Canada is coordinating its development. The Code is expected to be finalized by December 31, 1990. This code could be legally adopted by each of the provincial jurisdictions.

Initiative V304

Requirement that all large new tanks storing volatile organic liquids be equipped with state-of-the-art vapour control by 1993.

This measure requires 1) tanks with a volume greater than 150,000 litres and storing organic liquid with a true vapour pressure of 3.5 kPa or greater and 2) tanks with a volume greater than 75,000 litres and storing organic liquid with a true vapour pressure of 27.6 kPa to be equipped with a floating roof, closed vent system or any other control system capable of reducing uncontrolled emissions by 95% or more.

Tanks with a volume greater than 50,000 litres storing organic liquids with a true vapour pressure of 76.6 kPa or greater will be equipped with a closed vent system or any system capable of reducing uncontrolled emissions by 98% or more.

This measure is similar to the New Source Performance Standard (NSPS) adopted by the U.S. EPA in 1984. The appropriateness of the above size limits will have to be studied.

Guidelines will be developed through the Canadian Council of Minister of the Environment (CCME) and adopted by the provincial jurisdictions or implemented through provincial permit systems. Environment Canada will act as coordinator for these guidelines which should be finalized by December 31, 1991.

Initiative V305

New source performance standard for process emissions from new organic chemical plants, effective 1994.

This measure requires that process emissions from organic chemical plants built after December 31, 1993 be controlled with a 98% efficiency.

This would also apply to the supplementary production from expanded facilities. Only individual process streams with VOC concentrations less that 20 ppm would be exempted.

Similar measures have been adopted or are proposed as NSPS by the U.S. EPA.

This measure will be established as guidelines through the CCME and adopted in provincial regulations or implemented in permit systems as required. Environment canada will coordinate the preparation of these guidelines with a target date for completion of December 31, 1992.

Initiative V306

New source performance standard for plastic processing, effective 1995.

This measure requires that major plastic processing plants built after December 31, 1994 control their process emissions with the best available

control technology. This would also apply to emissions resulting from suplementary production from expanded facilities.

The specifics of this measure need to be established in a CCME Guideline to be coordinated by Environment Canada. The target date for completion of the guideline is June 30, 1993.

Initiative V307

New source performance standard for sulphate process in pulp and paper plants, effective 1994.

This measure requires that emissions from the sulphate (kraft) process from pulp and paper plants built after December 31, 1993 be captured and controlled with the best available control technology. Emissions resulting from supplementary production from expanded facilities would also be covered by this measure.

The specifics of this measure will be established in a CCME guideline under the coordination of Environment Canada. The target date for completion of this guideline is December 31, 1992.

Initiative V308

New source performance standards for commercial/industrial paint application facilities, effective 1994.

Industrial paint applications include manufacturing plants where coatings are applied to automobiles, furniture, household appliances, farm machinery, building materials, fabrics and other products. Commercial paint applications include facilities such as automobile paint shops and furniture repair shops.

Add-on emission control devices, mainly incineration or adsorption, can reduce VOC emissions by 90-99% depending on the solvent type and content in the flue gas.

Initiative V308 involves identification of appropriate subcategories within the commercial/industrial paint applications sector for setting emission standards, evaluating control options and selecting emission control levels for each subcategory. The standards will be developed in consultation with the relevant stakeholders and be completed in the form of a CCME code or guideline by December 31, 1992. The code/guideline development will be coordinated by Environment Canada.

Initiative V309

New source performance and operating standards for printing ink manufacturers, effective 1994.

Most VOC emissions from printing ink manufacturing can be effectively controlled at the time of manufacture through use of high-efficiency collection and recovery equipment. Control efficiencies of 90-95% can he achieved.

Under Initiative V309, recommended emission standards, minimum standards of operation to minimize fugitive losses, solvent use reporting requirements and a summary of available emission collection and control equipment will be contained in a CCME environmental code to be implemented by provinces.

Development of the code will be coordinated by Environment Canada and involve consultation with provinces, ink manufacturers and other stakeholders. The code will be completed by June 30, 1993.

Initiative V310

New source performance standards for commercial/industrial printing facilities, effective 1994.

The two types of printing that have very little control at present are rotogravure printing and flexography printing, which together account for 80% of VOC emissions from the printing sector. Other types of printing are estimated to have VOC emissions about 60% controlled (6-4).

Available emission control processes such as carbon adsorption, condensation and incineration, have VOC reduction efficiencies ranging from 90-99%. To achieve maximum reduction, control systems must have effective fugitive solvent vapour gathering systems (hoods, enclosures, vents, etc.).

A CCME environmental code will be developed under Initiative V310 for implementation by provinces using provincial regulatory authorities and permit systems. The code will establish recommended emission limits and describe control options available to printing establishments to meet those limits. Environment Canada will coordinate the code development, with appropriate stakeholder consultation, and complete the code by June 30, 1993.

Initiative V311

New source performance standard for commercial/industrial degreasing, effective 1995.

Solvent degreasing (or solvent cleaning) is the physical process of using, in most applications, an organic solvent to remove grease, fat, oils, wax or soil from various metal, glass or plastic items. Degreasing is done as a preparatory step to subsequent operations such as coating, plating repair, assembly and machining.

Although product substitution for the solvent offers the greatest potential for reduction in VOC emissions from degreasing, add-on controls can achieve significant reductions at larger manufacturing facilities where centralized units can be employed. Also, degreasing equipment redesign or better operational procedures offer some VOC reduction.

It is estimated that industry wide average reductions of 20% by process changes and good operating practices and 30% by add-on control devices can be achieved. Under Initiative V311 a CCME environmental code will be developed containing emission limits based on an evaluation of available practices and technology, and a summary of technology options and good operating practices. The code will be completed by June 30, 1994 through a consultative process with appropriate stakeholders. Provinces will implement the code using provincial regulatory authority and/or permit systems.

Initiative V312

New source performance standard and manual on improved handling practices for dry cleaners, effective 1995.

Dry cleaning involves the cleaning of fabrics with, as the name suggests, nonageous organic solvents. The two general solvent types used are petroleum solvents and synthetic solvents, with synthetic solvents accounting for 75% of total dry cleaning solvent use in Canada.

The solvent itself is the primary VOC emission from dry cleaning operations. Solvent is given off by the cleaning process in the washing, drying and solvent recovery operations. Product substitution strategies such as alternative solvents, offer some potential for VOC emission reductions. The dry cleaning process could be altered or amended to achieve some VOC reduction primarily through enclosure of the whole dry cleaning sequence to minimize solvent losses. Better equipment maintenance and using good operating practices can have a significant impact on emissions. Add-on controls can also be effective in reducing VOC emissions. As with other operations, these add-on controls are more ideally used in larger facilities where centralized units can be installed.

A CCME environmental code will be developed defining emission limits and outlining available control options and good handling practices for dry cleaning facilities. The code development will involve stakeholder consultation and be complete by December 31, 1993. Coordination of the code development process will be by Environment Canada, implementation by the provincial governments.

b) Regional

Energy Conservation and Product Control (V400 Series)

Initiative V401

Urban transportation management plans designed to reduce VOC emissions -

all urban centres in LFV and WQC with population greater than 200,000 by 1992. [Same as N401]

Consumer Choice and Lifestyle (V500 Series)
Initiative V501

"Restricted activity day" programs in place in all urban centres with population greater than 500,000 by 1993 in the LFV and WQC. [Same as N501]

Source Control Initiative (V600 Series)
Initiative V601

Light duty vehicle inspection and maintenance programs and anti-tampering legislation in the LFV and WQC by 1993. [Same as Initiative N601]

See description for Initiative N601

Initiative V602

Reduction in gasoline volatility in 1992 in LFV, WQC, Nova Scotia and New Brunswick to:

62 kPa (9.0 psi) for June, July & August
72 kPa (10.5 psi) for May & September

This is one of the most effective VOC reduction initiatives in the plan, accounting for about 42 kt of VOCs in 2005, or 8% of all VOC reductions. These reductions are split between automobile hydrocarbon evaporative loss reductions (80%) and gasoline distribution system vapour loss reductions (20%).

Some provinces (Ontario, Quebec) have already imposed summertime volatility limits in 1989 and all plan to impose a 72 kPa volatility limit for the summer of 1990. The U.S. is expected to promulgate regulations soon after the proposed Clean Air Act Amendments are passed limiting summertime volatility nationwide in the U.S. to 9.0 psi (62 kPa).

The 62 and 72 kPa volatility limits in Initiative V302 will be implemented by the provinces involved. A slight shift in timing of

application of the volatility limits in the Atlantic provinces to June and September for 72 kPa, July and August for 62 kPa, is recommended. The cut-off date in September for all provinces could be September 15th, since serious ozone episodes beyond that date rarely occur.

Initiative V603

Requirement for vapour balancing and recovery at existing gasoline storage and transfer depots (bulk and marketing terminals) in the LFV and WQC by 1993.

This requires that all provisions outlined in V302 for new depots be implemented on existing depots in the LFV and WQC built prior to 1992.

Although this retrofit initiative applies only to the LFV and WQC at this time, it should be given serious consideration for large urban areas in other regions. It is not only very cost effective, but would provide broader access to equipped terminals and the opportunity for full implementation of Stage 1 controls as the population of new equipped service stations grows (Initiative V302).

The guidelines developed for new depots under V302 will be used as a bases for establishment of retrofit plans and schedules by the affected provinces. These will be in place in B.C., Ontario and Quebec by December 31, 1991.

Initiative V604

Requirement for gasoline delivery vapour balancing at existing service stations in the LFV and WQC, effective 1993.

This measure implies that existing service station tanks be equipped with the appropriate piping and fittings to allow the vapours to be transferred from the tanks to delivery trucks during gasoline delivery by December 31, 1992 in the Lower Fraser Valley and the Windsor- Quebec corridor.

This control technique has been in use in some part of the U.S.A. for 15 years and more. The adaptation of the equipment to colder climate is an aspect to be studied.

A code of practice is currently being developped through the Canadian Council of Minister of Environment (CCME). This code could be legally adopted by each of the provincial jurisdictions. Environment Canada is coordinating its development. The code is expected to be completed by December 31, 1990.

Initiative V605

Requirement for vehicle refuelling vapour balance at service stations - LFV, WQC:

- ***New stations from January 1st, 1993***
- ***Existing stations by December 31, 1995***

This measure requires that new and existing service stations be equipped with the piping and fittings necessary to ensure the transfer of gasoline vapour from vehicle tanks to service station tanks during the refuelling of the vehicle. This measure, known as Stage II control, would apply to the Lower Fraser Valley and Windsor-Quebec corridor.

Although it is a costly measure, it addresses roughly 40% of the gasoline marketing network total emissions.

A code of practice will be developed through CCME to ensure consistancy of the type of equipment used across Canada. Provincial jurisdictions may wish to formally adopt the code provisions by establishing regulations. Environment Canada will coordinate the preparation of this code which will be completed by December 31, 1991.

Initiative V606

Requirement that fugitive emission inventory and leak reduction programs be implemented at all refineries in urban areas by 1993.

It is estimated that equipment leaks are the major source of VOC emissions at petroleum refineries. About 80% of these emissions would come from valves, the most numerous pieces of equipment in these plants.

The proposed measure requires that all refineries in urban areas put in place a program to better estimate the fugitive emissions from their equipment as well as a program to reducing these leaks by December 31, 1992.

The US EPA has established that relatively low cost programs can reduce uncontrolled emissions by 80%. New programs being developed in the U.S. rely on statistical methods to minimize the frequency of monitoring of the valves but at the same time ensure maximum control of emissions. They also include the replacement of certain pieces of equipment on a cost effectiveness basis.

A Code of Practice for control of fugitive emissions from refineries will be developped through CCME. The Code will cover fugitive emissions control for the organic chemical industry as well (Initiative V608). This code will then be adopted by provincial authorities or implemented in provincial permit systems. Environment Canada will coordinate the preparation of the code with a target date for completion of December 31, 1991.

Initiative V607

Retrofit of existing organic chemical plant processes in the LFV and WQC to NSPS by 1996.

This measure requires that process emissions from existing organic chemical plants be controlled with a 98% efficiency by December 31, 1996 in the Lower Fraser Valley and Windsor-Quebec corridor. Process streams with VOC concentrations lower than 20 ppm would be exempted.

This requirement parallels the proposed new source performance standard (NSPS) for organic chemical plants to be built in Canada after 1993 (Initiative V305).

This is a relatively stringent measure considering that retrofitting of

existing plants is generally not easy and more expensive than the installing of control equipment during plant construction.

A plan to adopt the provisions established for the NSPS (proposed guidelines through CCME, Initiative V305) and establish performance standards and implementation schedules will be developed by each of the provinces by December 31, 1993.

Initiate V608

Requirement that fugitive emission inventory and leak reduction programs be implemented at Organic Chemical Plants in the LFV and WQC, & elswhere near large urban areas by 1993.

The proposed measure requires that organic chemical plants put in place a program to better estimate the amount fugitive emission released from their equipment as well as a program to reduce these leaks by December 31, 1992.

The U.S. EPA has established that programs can reduce uncontrolled emissions by 56%. New programs being developped in the U.S. rely on statistical methods to minimize the frequency of monitoring of the potentially leaking equipment but at the same time ensure a maximum control of emissions. They also include the replacement of certain pieces of equipment on a cost effectiveness basis.

A Code of Practice for this measure will be developed through CCME. It will cover fugitive emission control for petroleum refineries as well (Initiative 606). This code could then be adopted by provincial authorities through regulations or implemented in provincial permit systems. Environment Canada will coordinate the preparation or this code to be completed by December 31, 1991.

Initiative V609

Retrofit of major existing plastic processing plants in the LFV and WQC to NSPS by 1996.

This measure requires that major plastics processing plants located in the Lower Fraser Valley and Windsor-Quebec corridor control their process emissions with the best available control technology by December 31, 1995.

This requirement parallels the proposed national requirement for similar controls for new plants by 1995 (initiative V306).

The specifics of this measure need to be developed. The proposed CCME guidelines (initiative V306) for new sources will be adapted by the respective provincial authorities in order do define performance standards. Each province will develop a schedule for implementation by June 30, 1993.

Initiative V610

Retrofit of existing sulphate process in pulp and paper plants in the LFV and WQC to NSPS by 1997.

This measure requires that emissions from the sulphate (kraft) process of existing pulp and paper mills in the Lower Fraser Valley and Windsor-Quebec city corridor be captured and controlled with the best available control technology by December 31, 1996.

This requirement parallels the proposed national requirements for similar sources for new plants effective 1994 (Initiative V307).

The specifics of this measure need to be developed. The proposed CCME guidelines for new sources (Initiative V307) will be adapted by the provincial authorities in order to define performance standards. The provinces will also develop a schedule of implementation by December 31, 1993.

Initiative V611

Retrofit existing ink manufacturing facilities in the LFV and WQC to new source performance standards by 1996.

Retrofit emission limits will be established jointly by Quebec, Ontario and British Columbia by June 30, 1993. As part of the retrofit program, the CCME code for new sources defining good operating practices and control options will be disseminated to existing ink manufacturers. Each province will develop its own implementation schedule and its own reporting procedures by June 30 1993.

Initiative V612

Retrofit existing rotogravure and flexography printers in the LFV and WQC to new source performance standards by 1996.

Rotogravure and flexography printing together represent 92% of all VOC emissions from the printing sector. About 50% of the rotogravure printing facilities and only about 10% of the flexography printing facilities are estimated to have add-on controls (NO_x/VOC Workgroup on Control Technologies).

Add-on controls are capable of reducing VOC emissions from these types of printing facilities by 90%. Quebec, Ontario and British Columbia will jointly develop a retrofit emission limit for rotogravure and flexography printing that could subsequently be extended to other provinces at their discretion. Retrofit schedules and reporting mechanisms within each of the three initiating provinces will be de developed independently taking into account the characteristics of the facilities in each province by June 30, 1993.

Initiative V613

Retrofit existing commercial/industrial degreasing operations in the LFV and WQC to new source performance standards by 1997.

Degreasing operations are described under Initiative V311.

Initiative V613 would be confined to the larger manufacturing units where centralized add-on controls can be retrofitted.

Establishment of the retrofit limits, schedules and reporting requirements would follow a procedure similar to that outlined for Initiative V612. It will have to be completed by December 31, 1993.

Initiative V614

Retrofit existing dry cleaners in the LFV and WQC to new source performance standards by 1997.

Dry cleaning operations are described under Initiative V312. Initiative V614 will be limited to larger facilities where centralized add-on controls can be installed. A process similar to that for Initiative V612 will be followed in defining the retrofit limits, facilities involved, retrofit schedule and reporting requirements. These will be developed by December 31, 1993. As a supplement to the retrofit program, all provinces will disseminate the environment code outlining good operating practices for new dry cleaning facilities to existing dry cleaning operators.

Initiative V615

Retrofit improved emission controls for wood waste burning in the LFV by 1995 and ban the practice entirely during ozone episodes beginning in 1991.

Woodwaste burning is a significant VOC source only in British Columbia. Without additional control, wood waste burning will be the 5th largest VOC source in the LFV region.

The retrofit schedule within the 1995 target date, retrofit emission limits and the mechanism to prohibit wood waste burning during ozone episodes will be developed by British Columbia in consultation with the appropriate stakeholders by December 31, 1992.

VI.4 Description of Studies and Investigations for Second Edition of Plan

Emission Inventories and Forecasts (S100 Series)

Initiative S101

Streamline emission inventories with automated provincial reporting to establish a maximum one year lag time by 1993.

Currently, comprehensive national NO_x and VOC inventories are 3 to 4 years behind by the time they are published. This is unacceptable. It is also unnecessary given todays electronic technologies.

Achieving more up-to-date emission inventories on a routine basis is an organizational problem, not a technical one. It requires more streamlining and automation up front so that all jurisdictions can input to a common system in a common format. It means acceptance by all jurisdictions of a common emission estimation methodology, with a forum to update the methodology as knowledge advances.

Initiative S101 involves getting the mechnisms and procedures in place to generate the previous years emission data within the current year. It requires cooperation by all jurisdictions to obtain and analyze essential data for developing inventories. Information suhc as industrial production statistics and statistics on the penetration of new technologies must be accessible in a timely manner from each jurisdiction. More work is required to ensure that all air emissions inventories carried out by regional, provincial and federal agencies are integrated, and that the database systems and inventory in formation are compatible and comparable.

Initiative S101 will be coordinated by Environment Canada and use the mechanism of the current Inventories Subcommittee of the Federal/Provincial Advisory Committee on Air Quality.

Initiative S102

Update the national emission forecast annually, extending it to 2010.

Factors affecting emission forecasts are known to change rapidly. Recent evidence of this is the change in NO_x emissions from heavy duty vehicles as a result of running the new MOBILE 4 model and revising various assumptions on

automobile performance. Similarly, major changes can occur in NO_x emissions from power plants as electricity demand, economic growth, energy supply options and import/export assumptions change.

Emissions and emission forecasts are fundamental to designing emission control programs. Under Initiative S105, May of each year will be target as the delivery date for updated NO_x and VOC forecasts, each covering no less than a 15 year forecast period.

Initiative S103

Conduct emission surveys for the pulp and paper, plastics processing and wood transformation sectors.

Emissions from these sectors are based on generic emission factors. Individual plant emissions are not available in most cases.

There is need for more accurate emission data in order to establish the reductions that could be made and where they would take place.

Surveys for the pulp and paper and plastics processing sectors will be conducted by Environment Canada. The survey for the wood transformation sector will be conducted by the British Columbia Ministry of the Environment since the preliminary data indicate most emissions from this sector are released in that province.

The final results of the survey have to be available by the end of 1991 in order to proceed with the application of controls.

Initiative S104

Develop a more accurate data base on emissions from products containing solvents (pesticides, general solvent use, etc.)

Solvent use is estimated to be the largest source of VOCs nationally, and will be even more prominent as VOC emissions from the other dominant source, motor vehicles, declines.

Improved inventories of VOC emissions are needed for virtually all solvent use categories. Priority should be given to general solvent use, glues and adhesives, and consummer products categories.

Additional solvent control is expected to be a focus of the Second Edition of the Plan. The data obtained under Initiative S104 will provide the bases for selecting solvent use categories for control and designing a better VOC control program.

Initiative S105

Determine the number and usage rates of off-road vehicles.

Most emission data for off-road sources is derived from fuel use and antiquated emission factors found in AP-42. While this may be adequate for on overall yearly inventory it does not allow a reasonable estimate of the cost and benefits of regulation. The present information on the number, spacial distribution and use of off-road equipment is non-existent or woefully inadequate for most off-road sources. While there is a good deal of data available on the number and location of farm tractors in Canada from the census, very little data exists on the number, type and location of other off-road equipment. There is a need to identify the number and usage rates for all mobile sources and IC engines in order to be able to use the information on emission rates that will become available as a result of studies in support of regulations in the U.S.

Initiative S106

Prepare refined sets of emission inventory data for the WQC with aereal resolution to facilitate oxidants modelling.

Detailed NO_x and VOC emission data with a small spatial resolution has already been generated for the LFV. Data needs to be developed for the WQC with spatial resolution compatible with the input data requirements of the most promising regional and urban oxidants models. It is generally accepted that

model grid sizes in the order of 20 km square for regional oxidant modelling and 2-10 km square for urban area oxidant modelling are required.

Initiative S106 will provide appropriately NO_x and VOC emission data to effectively model ozone episodes in the WQC by December 31, 1991.

Ambient Air Quality Modelling (S200 Series)

Initiative S201

Analyze available ambient air monitoring data to obtain additional information on ozone episode characteristics.

It is believed that much more can be learned by further analysis of ambient air quality and meteorological data already available, without doing further oxidants modelling.

Available data will be extracted, analyzed and presented in different ways with the view of obtaining additional insight on transboundary flux of NO_x, VOCs and O_3, episode characteristics as they track through regions, regional diurnal O_3 profiles during typical episodes and other information that will improve the general understanding of ground-level ozone. This analysis will also attempt to explain the descrepancy between VOC/NO_x ratios for emissions and VOC/NO_x ratios for ambient air.

Initiative S202

Obtain better information on the transboundary flow of NO_x, VOCs and ozone and the penetration of these pollutants into various segments of the LFV and WQC.

There is currently very little data available for the different segments of the WQC on the proportion of NO_x, VOCs and O_3 in ambient air that originates from the United States during typical ozone episodes. This is particularly true for ambient air concentrations during the daytime.

Initiative S203 will obtain better information on diurnal variations of ambient air NO_x and VOCs, analysis of reaction rates and transport distances

for NO_x, VOCs and ozone during selected historical events and prediction of how much of each is likely to remain in a reactive form at different Canadian locations, analyses of whether low level sources of NOx and VOCs are likely to be transported long distances in a reactive form, and how much NO_x is likely to enter Canada as NO_2 from distant elevated sources such as power plants.

This work will be completed by December 31, 1991.

Initiative S203

Prepare refined meteorological data sets for the WQC with aereal resolution to facilitate oxidants modelling.

One of the reasons for not being able to run an oxidants model with a smaller grid size than the 127 km square grid used by the ADOM model is the lack of meteorological data on a smaller grid bases.

Initiative S202 will involve developing the meteorological data, by June 30, 1991, on an appropriate grid size for the WQC modelling domain. The grid size will be not greater than 20 km square for the region with finer urban area resolution as determined by the modellers.

Initiative S204

Set up and run appropriate scale oxidants models for the LFV and WQC, preferrably with grid sizes for episode modelling not greater than 20 km X 20 km for rural areas and 10 km X 10 km for urban areas.

It has been concluded (6-1) that spacial resolution of data to sizes not greater than those listed in Initiative S204 is needed to provide a reasonable portrayal of the magnitude and aereal distribution of NO_x and VOC emissions and ambient air concentrations. The magnitude and aereal distribution in turn effects oxidant forming re tion rates and the similated ground level ozone episode profiles that are p icted by the oxidants model.

Initiative S204 involves (1) in the short term (by June, 1991) extending the Regional Oxidants Model (ROM) being run by the U.S. EPA for the

northeastern states into Canada and completing selected model runs with different NO_x and VOC control levels in Canada and (2) in the longer term (by June, 1993), establishing an appropriate practical operating model for at least the LFV and WQC regions, and completing model runs to better predict the near-field and far-field effects of NO_x and VOC controls in different parts of these regions. These will include runs with different boundary condition assumptions to reflect predicted trends in the transboundary flow of NO_x, VOCs and ozone during episodes as a result of U.S. control programs.

Technologies, Control Options and Costs (S300 Series)

Initiative S301

Refine the cost estimates for VOC emissions control for large sources (organic chemical plants, etc..).

Current cost estimates for large sources of VOCs are mostly based on U.S. data. In some cases, the data are more than five years old. The effect of colder climate requirements on cost has not been taken into account. All these factors require further studies.

Another aspect of the cost of control which has not been explored yet for large sources is the relationship between effectiveness of a given measure and the size of the source being regulated.

This study will be coordinated by Environment Canada. It is expected that relevant industrial sectors will fully co-operate and substantially contribute to the financing of the studies.

Final results will be needed by the end of 1991.

Initiative S302

Evaluate the type and extent of VOC emission controls currently employed in the plastics processing, pulp and paper and wood transformation industries.

Preliminary work in this area, by the NO_X/VOC Workgroup on Control Technologies has not been able to clearly identify the control techniques currently employed in Canada or elsewhere.

The plan calls for controls on these sources starting in 1993. Control technologies available need to be identified to establish the reductions achievable as well as the cost effectiveness of these measures.

These studies could be conducted in parallel with initiative S103 studies. Results are needed by the end of 1991.

Initiative S303

Conduct periodic reviews and joint government/industry R&D on advanced combustion and NO_X emission control technologies.

Rapid development of new combustion processes and flue gas clean up technologies for NO_X is expected over the next decade, aided by efforts in industrialized countries around the world to reduce NO_X, SO_2 and CO_2 emissions. Technologies for the control of one pollutant will often affect emissions of other pollutants.

Initiative S303 will involve a continuing review during the next 5 years of new combustion process and NO_X control technology developments, with particular attention to those that have multi-pollutant control potential. This evaluation will include stage of development, costs and suitability for penetration into Canadian industries. In addition, joint government industry research and demonstration will be conducted on selected technologies to increase industry and regulatory agency knowledge and awareness of opportunities, and hopefully influence the more rapid penetration of advanced technologies into the Canadian market.

Initiative S304

Evaluate the extent of current control and product substitution in all major solvent use categories.

A major weakness in the current inventory of VOC emissions from solvent use is lack of information on the extent of application of emission control technologies in the different solvent use categories. In addition, information on product substitution plans already being contemplated by industry has not been obtained and analyzed, but is pertinent to evaluation of potential VOC control opportunities.

Initiative S304 will involve surveys of selected solvent use categories to better characterize current practices and intentions of industry. This work will be completed by June 30, 1991.

Initiative S305

Evaluate the additional control and product substitution options available for major solvent use categories.

One of the reasons why the plan calls for only modest reductions in VOC emissions from solvent use is that there is considerable uncertainty on the options available and how quickly they could be implemented in the various solvent use categories.

Initiative S305 will involve an indepth evaluation of both currently available and developing VOC emission control and product substitution options, development of reasonable projections on how fast they could penetrate the Canadian market, and development of proposals on actions needed to stimulate that penetration. The target date for completion of this work is June 30, 1991.

Initiative S306

Evaluate measures planned or implemented under the greenhouse gas control program and their implications for NO_x and VOC emissions.

Many of the options available to reduce greenhouse gas emissions will also reduce NO_x and VOC emissions, particularly NO_x emissions. There is a need to maintain an ongoing review and periodic evaluation of initiatives to control

greenhouse gases over the next 4 years so that adjustments to the Plan in 1994 will take full account of and be complementary to the greenhouse gas control program. Part of this will be covered in the annual updates to NO_x and VOC emission forecasts. However, there are many potential greenhouse gas control initiatives that will require specific evaluation with respect to implications for NO_x and VOC emissions to better appreciate multi-pollutant reduction opportunities.

Initiative S306 will involve selected evaluations as greenhouse gas control initiatives become known such that an up-to-date analysis of the interface can be brought forward when discussions on the Second Edition of the plan begin.

Initiative S307

Analyse Canadian passenger and goods transport networks to determine potential for intermodel shifts on major arteries to reduce CO_2, NO_x and VOCs.

Transportation is a major source of VOC and NO_x emissions in urban areas of Canada. Tail pipe emission standards have been the preferred way to address this source up to now. Another means of reducing emissions from the transportation sector is to improve the transportation network by ensuring that passengers and goods are transported in a less polluting fashion.

Initiative S307 will involve the in depth analysis of current passenger and good transport networks to determine the potential improvements that can be made environmentally, what the associated emission reductions would be, what measures would be needed to facilitate the occurence of these changes as well as their costs. The target date for the completion of this study is December 31, 1991. Transport Canada and Energy, Mines and Resources Canada will conduct the study.

U.S. Emission Control (S400 Series)

Initiative S401

Analyze the new U.S. NO_x control program for NO_x reductions in selected

regions (Ohio Valley, Great Lakes, eastern seaboard, Puget Sound, etc.) between now and 2010.

It is identified in the plan that we will not achieve attainment of ozone air quality objectives in all regions of Canada unless significant NO_x and VOC reductions occur in the United States. Because Canada is most affected by pollutants eminating from a few select regions of the U.S, it is imperative that we better understand what the trends in emissions in these regions over the next 15-20 years is likely to be. For example, there is a concentration of power plants in the Ohio Valley which collectively produce more NO_x than is produced nationwide in Canada from all sources.

Initiative S401 involves an evaluation of the trends in NO_x emissions in selected regions as a result of anticipated U.S. control actions. It will begin within 6 months after passage of the proposed U.S. Clean Air Act amendments (latest anticipated timing is fall, 1990) with a report in 6 months from that date and a subsequent update in 1993 before discussions begin on the Second Edition of the plan.

Initiative S402

Analyze measures in, and track implementation of, State Implementation Plans (SIPs) for selected ozone non-attainment areas in the U.S. (Seattle, Michigan, Ohio, New York, etc.)

The success of certain SIPs is fundamental to improving air quality in some regions of Canada. It is important to understand what they are likely to achieve if fully implemented and whether they are being implemented as planned, which has been a problem in the past. There may be opportunities to encourage special attention in the U.S. to SIPs of particular interest to Canada.

Initiative S402 involves an indepth review of measures and timing of implementation of selected SIPs, and estimation of VOC and regional ozone reductions that are likely to result. This work will be completed by December 31, 1992.

Initiative S403

Analyze any plans by Detroit to develop a stable methanol supply in response to the new U.S. Clean Air Act legislation, and opportunities to work jointly with Detroit in using this supply for penetration of methanol fuelled vehicles into southern Ontario.

Proposed amendments to the U.S. Clean Air Act included minimum numbers of alternative fuel vehicles into key ozone non-attainment areas at selected dates between now and year 2000. A southern Ontario market for such vehicles might improve the attractiveness of an alternative fuel vehicle program in the Detroit area, and provide an opportunity for motor vehicle VOC reductions in Canada. Methanol is one of the more promising alternative fuels, but its use requires establishment of a stable, accessible supply.

Initiative S403 will involve a preliminininary review by December 31, 1991 of the likelihood of an alternative-fuel vehicle program in the Detroit area with followup analysis of Canadian opportunities if plans to develop a stable methanol supply evolves.

VII Post-Plan NO_x and VOC Emissions

Projected emissions of NO_x and VOCs in 2005 with and without implementation of the plan are listed in Tables 14 and 15. The tables also show the breakdown between reductions achieved through national and regional initiatives in each of the source categories. Source categories nationally and for each of the three regional study areas are listed in order of projected pre-plan quantity of emission in 2005.

It is of interest to note the magnitude of the remaining emissions from the various sectors after both national and regional control initiatives have been applied. If additional NO_x control is contemplated, it would appear that in both the LFV and WQC, heavy duty vehicles, selected industrial processes and selected off-road diesel engine categories would be prime candidates. Also some of the smaller source categories not dealt with in the plan initiatives, such as railroads, aircraft and marine, could be considered for control.

In terms of additional opportunities for reducing VOC emissions, the focus would be on selected categories of solvent use, selected industrial processes, off-road gas and marine. After implementing the plan, solvent use VOC emissions will be more than double the VOC emissions from any other source in both the WQC and LFV.

To provide an additional perspective on the geographic implications of the plan, emission reductions and post-plan emissions are presented by province in Tables 16 and 17.

Table 14 Pre-Plan and Post-Plan NO_x Emissions (Kt/Yr) DRAFT

Area	1985	2005 Pre-Plan	2005 After Nat. Plan Initiatives	2005 After Nat. & Reg. Plan Initiatives
Lower Fraser Valley (LFV)				
LDVs	34.4	16.5	12.1	11.4
HDVs	28.1	16.1	14.8	14.1
Ind. Processes	3.7	15.5	15.5	15.5
Comm/Ind. Fuel Comb.	9.2	12.2	9.4	9.1
Off Road Diesel	6.4	8.1	7.7	7.7
Res. Fuel Comb.	1.9	1.8	1.6	1.6
Marine	1.0	1.6	1.6	1.6
Railroads	1.7	1.3	1.3	1.3
Power Gen.	3.7	1.2	1.0	0.2
Aircraft	0.3	0.5	0.5	0.5
Other	2.3	2.6	2.6	2.6
	92.7	77.4	68.1	65.6
Windsor-Quebec Corridor (W-Q)				
LDVs	196.8	117.1	81.2	76.8
HDVs	92.4	97.1	89.3	84.9
Power Gen.	91.5	93.4	93.4	36.2
Comm/Ind. Fuel Comb.	58.6	83.1	57.1	54.3
Off Road Diesel	43.3	64.6	61.1	61.1
Ind. Processes	34.3	55.9	55.9	55.9
Res. Fuel Comb.	17.9	15.7	14.1	14.1
Aircraft	9.6	13.0	13.0	13.0
Marine	10.7	12.5	12.5	12.5
Railroads	4.7	3.7	3.7	3.7
Other	12.4	15.1	15.1	15.1
	572.2	565.2	496.4	427.6
Saint John Area (SJA)				
Power Generation	3.2	15.7	13.4	13.4
Comm/Ind. Fuel Comb.	2.7	3.8	3.0	3.0
Industrial Processes	1.4	2.2	2.2	2.2
HDVs	1.9	2.2	2.0	2.0
Off Road Diesel	1.2	1.7	1.7	1.7
LDVs	2.3	1.1	0.8	0.8
Other	0.8	1.1	1.1	1.1
	13.5	27.8	24.2	24.2
National				
Power Generation	247.9	351.7	282.9	224.9
Off Road Diesel	230.4	317.4	309.5	309.5
HDVs	285.2	260.8	239.9	234.8
LDVs	453.1	238.2	174.2	169.1
Comm/Ind. Fuel Comb.	145.2	207.3	134.0	130.9
Industrial Processes	89.0	139.7	139.7	139.7
Railroads	132.1	113.0	113.0	113.0
Natural Gas Ind.	158.8	112.5	98.0	98.0
Aircraft	33.4	42.3	42.3	42.3
Residential Fuel Comb.	41.5	36.9	33.2	33.2
Off Road Gas	30.4	28.7	28.7	28.7
Marine	14.9	18.5	18.5	18.5
Other	25.0	35.7	35.7	35.7
	1886.9	1902.7	1649.6	1578.3

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Table 15 Pre-Plan and Post-Plan VOC Emissions (Kt/Yr)

Area	1985	2005 Pre-Plan	2005 After Mat. Plan Initiatives	2005 After Mat. & Reg. Plan Initiatives
Lower Fraser Valley (LFV)				
Solvent Use	28.3	32.5	18.6	17.2
Light Duty Vehicles (LDVs)	45.0	26.7	25.5	16.0
Ind. Processes	6.2	11.3	10.0	8.1
Marine	3.8	6.5	6.5	6.5
Gas Distribution	6.6.	6.1	5.4	0.3
Ind. Fuel Comb.	4.3	5.6	5.6	5.6
Heavy Duty Vehicles (HDVs)	6.5	3.2	3.2	3.2
Offroad Gas	2.8	3.0	3.0	3.0
Fuelwood Comb.	2.0	2.7	2.7	2.7
Aircraft	0.7	1.1	1.1	1.1
Other	7.9	9.9	9.9	9.9
	114.1	108.6	91.5	73.6
Windsor-Quebec Corridor (WQC)				
Solvent Use	263.3	327.1	236.3	226.1
Ind. Processes	122.9	199.0	155.4	84.2
Light Duty vehicles (LDVs)	236.1	165.0	157.3	98.9
Fuelwood Comb.	54.4	69.5	69.5	69.5
Gas Distribution	50.4	63.9	56.9	14.0
Offroad Gas	19.6	25.7	25.7	25.7
Heavy Duty Vehicles (HDVs)	13.8	17.1	17.1	17.1
Marine	11.9	11.9	11.9	11.9
Aircraft	3.0	4.1	4.1	4.1
Other	19.4	25.1	25.1	25.1
	794.8	908.4	759.3	576.6
Saint John Area (SJA)				
Solvent Use	2.3	2.6	1.5	1.5
Fuelwood Comb.	2.1	2.4	2.4	2.4
Ind. Processes	1.6	2.2	1.6	0.8
Light Duty Vehicles (LDVs)	2.6	1.5	1.4	1.1
Gas Distribution	0.6	0.7	0.7	0.6
Heavy Duty Vehicles (HDVs)	0.4	0.4	0.4	0.4
Marine	0.3	0.3	0.3	0.3
Offroad Diesel	0.1	0.3	0.3	0.3
Offroad Gas	0.2	0.2	0.2	0.2
Other	0.3	0.2	0.2	0.2
	10.5	10.8	9.0	7.8
National				
Solvent Use	502.0	602.9	400.8	389.2
Ind. Processes	223.4	394.9	293.2	217.1
Light Duty Vehicles (LDVs)	556.8	349.9	333.6	260.6
Fuelwood Comb.	107.7	132.7	132.7	132.7
Slash Burning	80.6	129.0	129.0	129.0
Gas Distribution	109.0	124.4	109.3	60.4
Offroad Gas	66.1	74.3	74.3	74.3
Ind. Fuel Comb.	49.5	63.9	63.9	63.9
Heavy Duty Vehicles (HDVs)	53.8	47.8	47.8	47.8
Offroad Diesel	23.4	34.8	34.8	34.8
Marine	27.9	31.5	31.5	31.5
Aircraft	10.1	13.2	13.2	13.2
Railroads	7.0	6.0	6.0	6.0
Other	36.2	42.1	42.1	42.1
	1853.5	2047.4	1712.2	1502.6

TABLE 16 - PROVINCIAL NO_x EMISSION REDUCTIONS (KT/YR 2005)

Province/Territory	1985	Reductions in 2005							Total	2005 Pre-Plan	2005 Post-Plan
		LDVs	HDVs	Off Rd. Diesel	Elect. Power	Nat. Gas	C/Ind. Fuel Comb.	Res. Fuel Comb.			
British Columbia	252.6	9.1	3.1	0.7	1.0	5.4	13.6	0.3	33.2	225.4	192.2
Alberta	440.3	6.6	2.0	1.4	38.5	0	8.6	0.7	57.8	435.6	377.8
Saskatchewan	155.6	3.1	1.8	0.5	10.6	9.1	2.8	0.2	28.1	165.5	137.4
Manitoba	81.9	3.0	1.7	0.4	0.1	0	1.7	0.1	7.0	77.0	70.0
Ontario	557.5	29.3	9.8	3.5	57.2	0	30.8	1.5	132.1	553.6	421.5
Quebec	222.8	13.1	4.5	0.9	0.5	0	12.8	0.4	32.2	218.3	186.1
New Brunswick	46.4	1.5	0.9	0.1	12.5	0	2.4	0.1	17.5	80.7	63.2
Nova Scotia	74.3	1.9	1.3	0.1	4.1	0	1.9	0.2	9.5	82.9	73.4
Prince Edward Island	5.6	0.3	0.2	<0.1	<0.1	0	0.1	<0.1	0.7	5.4	4.7
Newfoundland	33.7	1.0	0.6	0.1	0.9	0	1.6	0.1	4.3	36.2	31.9
Yukon/N.W.T.	16.0	0.2	0.1	0.2	1.3	0	0.1	<0.1	2.0	22.1	20.1
CANADA	1886.9	69.1	26.0	7.9	126.8	14.5	76.4	3.7	324.4	1902.7	1578.3

TABLE 17 - PROVINCIAL VOC EMISSION REDUCTIONS (KT/YR - 2005)

Province/Territory	1985	Reductions in 2005						2005 Pre-Plan	2005 Post-Plan
		LDVs	Gas Dist^{n}	Vol. Liq. Storage	Ind. Process	Solvent Use	Total		
British Columbia	294.7	11.8	6.5	2.3	3.0	21.9	45.5	305.4	259.9
Alberta	229.2	1.5	1.5	2.1	45.6	13.6	64.3	266.7	202.4
Saskatchewan	83.9	0.8	0.5	0.6	0	6.3	8.2	73.7	65.5
Manitoba	71.0	0.8	0.5	0	0	6.4	7.7	59.8	52.1
Ontario	652.7	45.9	35.2	6.8	70.8	100.7	259.4	752.5	493.1
Quebec	372.1	22.2	17.6	2.8	41.2	49.8	133.6	421.3	287.7
New Brunswick	45.4	2.6	0.8	0.5	0.8	4.5	9.2	47.9	38.7
Nova Scotia	52.2	3.4	1.0	1.3	0	5.4	11.1	51.3	40.2
Prince Edward Island	11.0	0.1	0.1	0	0	1.0	1.2	11.2	10.0
Newfoundland	35.6	0.2	0.3	0	0	3.7	4.2	49.3	45.1
Yukon/N.W.T.	7.0	<0.1	<0.1	0	0	0.4	0.4	8.3	7.9
CANADA	1853.5	89.3	64.0	16.4	161.4	213.7	544.8	2047.4	1502.6

VIII Effectiveness of the Plan

VIII.1 Effectiveness in Resolving Domestic Ground-Level Ozone Problems

a) Peak Ozone Concentrations

Pending more detailed analysis with a reliable oxidants model, estimates have been made (Table 18) on what the plan is likely to achieve in terms of ozone reduction in the three selected study areas. These are based on Tables 7 and 8 in Section V.1 and general assumptions on local versus long range transport influence.

Table 18 Predicted Peak Ozone Concentrations After Implementing the Management Plan

Region	Plan Emission Reductions Below 1985(%) NO_x	VOC[1]	Approx. Percent O_3 Reduction	Peak Ozone Concentrations (ppb) Pre-Plan (1985)	Post-Plan (2005)
LFV	29	35 (44)			
- Vancouver			25-35	60-210	40-160
- Chilliwack			25-35	80-120	60-80
WQC	25	27 (34)			
- Windsor			0	100-160	100-160
- Toronto			10-20	80-190	65-170
- Montreal			15-25	60-180	50-140
- Quebec			15-25	60-160	50-120
SJA	-79[2]	25 (31)			
- Saint John			10-20	80-100	70-90

1 % VOC emission reductions shown in brackets () have been used to estimate O_3 reduction. They are 25% higher than the annual average to account for greater reduction during the daytime in summer due to the seasonal nature of some VOC controls such as fuel volatility reduction.

2 See footnote Table 11. Ozone reduction is based on a 12% NO_x reduction (no. for "rest of Canada") which is more representative.

As shown in Table 18, reductions in peak ozone levels ranging from no reduction at the southern end of the WQC to reductions up to 35% in the LFV are predicted. Depending on the extent of long range transport, excursions above 82 ppb would be essentially eliminated up the Fraser Valley east of

Vancouver. In other locations in all three regions, ozone peaks well above 82 ppb will still occur. The frequency of exceedances and the total number of hours per year above the maximum acceptable O_3 objective should be substantially reduced as shown below.

b) Hours Above Maximum Acceptable Ozone Level

Relationships between hours greater than 82 ppb and ozone peaks have been derived for both the LFV and WQC regions (Figures 24 and 25). The number of hours per year greater than 82 ppb can be expected to be reduced by greater percentages than the percentage reduction in peak ozone levels. The data in Table 19 has been derived from these relationships.

TABLE 19 RELATIONSHIP BETWEEN CHANGE IN MAX. OZONE VS CHANGE IN HRS>82 ppb (BASED ON EQUATIONS FROM FIGURES)

MAX1 (ppm)	MAX2 (ppm)	% Change	No.Hrs1	No.Hrs2	% Change
	Windsor-Quebec City (Average 83-89)				
0.160	0.144	-10%	115	92	-20%
0.160	0.128	-20%	115	69	-40%
0.140	0.126	-10%	86	66	-23%
0.140	0.112	-20%	86	46	-47%
0.120	0.108	-10%	57	40	-30%
0.120	0.096	-20%	57	23	-61%
0.100	0.090	-10%	28	14	-51%
0.100	0.080	-20%	28	0	-102%
	GVRD-Fraser Valley(Average 83-89)				
0.160	0.144	-10%	24	19	-18%
0.160	0.128	-20%	24	15	-36%
0.140	0.126	-10%	18	15	-20%
0.140	0.112	-20%	18	11	-41%
0.120	0.108	-10%	13	10	-25%
0.120	0.096	-20%	13	7	-49%
0.100	0.090	-10%	8	5	-35%
0.100	0.080	-20%	8	2	-69%

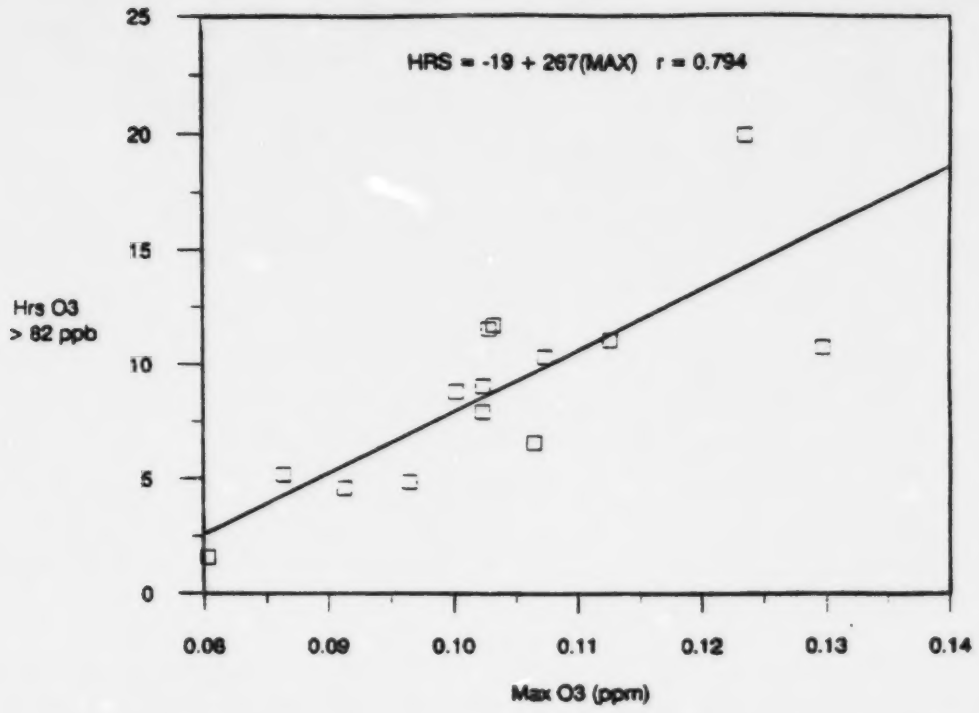

FIGURE 24 RELATIONSHIP BETWEEN MAXIMUM OZONE AND HOURS > 82 ppb - GVRD/LFV

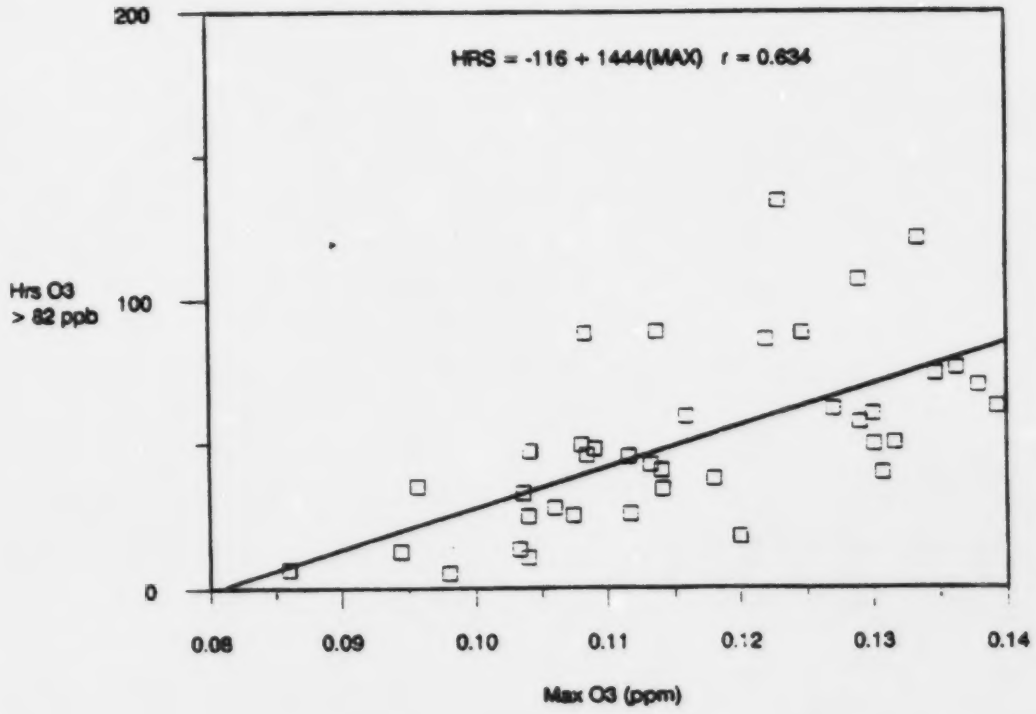

FIGURE 25 RELATIONSHIP BETWEEN MAXIMUM OZONE AND HOURS > 82 ppb - WQC

Applying the relationships to pre-plan ozone peaks (average of 3 highest years) at various locations provides an indication of reductions in hours above 82 ppb that might be expected in an average year at these locations. The results of this analysis are presented in Table 20.

Table 20 Estimated Reduction in Ozone Hours > 82 ppb

Location	Plan Red in Peak (%)	O_3 Peak (ppb) (Avg. 3 High Yrs) Pre-Plan	Post-Plan	Plan Red Hrs >82 ppb (%)	Annual Hours>82 ppb (Avg. 3 High Yrs) Pre-Plan	Post-Plan
LFV						
- Vancouver	30	120	84	74	13	3
- Chilliwack	30	120	84	74	13	3
WQC						
- Windsor	0	150	150	0	160	160
- Toronto	15	160	136	30	105	75
- Stouffville	15	130	112	40	100	60
- Montreal	20	125	100	55	50	30
- Quebec	20	110	88	75	15	3
SJA						
- Saint John	15	95	80	100	25	0

This suggests that in the LFV region there would be few exposures to O_3 levels above 82 ppb in average years. The occasional year with an unusually high O_3 peak would still occur with short duration exposures (10-15 hours) to O_3 concentrations greater than 82 ppb. Up the Fraser Valley, exceedances of the 82 ppb level would be rare.

In the WQC, hours above the 82 ppb level would remain high in Windsor, Long Point and other parts of southern Ontario. In the Toronto area, hours above 82 ppb would be down about 35% in average years. Between Toronto and Montreal, hours above 82 ppb would be reduced by 40-75% depending on distance downwind of Toronto. Montreal would have a 50-60% reduction in average years, probably with few hours above 82 ppb in at least half of the years. Years with O_3 above 82 ppb in the areas between Montreal and Quebec and in Quebec City would be rare.

c) Growing Season Ozone Concentrations

Only a rough generalization can be made of the probable reductions in ozone concentrations throughout the growing season as a result of implementing the plan.

It is likely that mean ozone concentrations in the major NO_x and VOC source areas over the growing season will be reduced to a much lesser degree than peak ozone levels. Analyses carried out with ROM have shown that NO_x and VOC reductions have the most impact on peak ozone concentrations and a much smaller impact on long-term average concentrations such as growing season means (Reference). Model results in Europe showed that 50% NO_x and 50% VOC reductions reduced the number of hours with ozone levels >120 ppb by 100% but reduced the number of hours >60 ppb by only 2% (FRG 1989, Zierock 1988). As shown in Figure 15, rural O_3 formation in the east is expected to be NO_x limited and photochemical production of ozone is quite insensitive to anything but large changes in NO_x concentrations. VOCs are resually in ample supply due to the presence of biogenic VOCs and less reactive long-lived anthropogenic VOCs. Rural ozone is also affected by background troposheric ozone levels which, as discussed in Section V.1, are also elevated due to anthropogenic emissions.

With NO_x and VOC reductions resulting from implementing the plan, growing season mean O_3 concentrations are not likely to be reduced more than 10% anywhere. However, the reductions may occur over fairly large geographic areas. Even with a modest percentage reduction in the growing season mean, areas that may be considered at risk from potential ozone-related vegetation damage may be reduced substantially. It is worth noting that studies on crop damage often consider effects of relatively small percentage reductions (50 to 40 ppb- 20%) in growing season O_3. Hence, even small percentage reductions would be beneficial.

VIII.2 Effectiveness in Reducing Emissions of Toxic VOC

Many of the VOC sources to be controlled under the plan contain VOC species that are of concern because of known or suspected toxicity. More than half of the substances on the Priority Substances List (PSL) of the

Canadian Environmental Protection Act and now under assessment for toxicity are VOCs. Examples are benzene, toluene and xylene which are constitutents of gasoline and numerous solvents used in such processes as dry cleaning, surface coating and industrial degreasing. Benzene occurs in emissions from automobiles, refineries, gasoline distribution and organic chemical plants, all of which are identified for control in the plan. Similarly, control measures are proposed for a number of solvent use categories.

Overall the plan calls for a VOC reduction of 19% from the 1985 emission level. In total, VOCs of concern because of there toxicity rather than their reactivity in forming ozone should be reduced by roughly the same amount. The plan calls for a reduction in VOC emissions of 22% from solvent use, 57% from refineries, 45% from gasoline distribution systems and vehicle refueling, and 38% from organic chemical plants. The plan will contribute a 16% VOC reduction from automobiles, which when added to the 37% reduction expected with current controls, will result in automobile emissions of VOCs 53% below current levels by 2005.

Indoor VOCs have been identified as a greater concern from a human health perspective than outdoor VOCs (NO_x/VOC Worgroup on Effects). Reductions called for in the plan for various solvent use categories such as paints and coatings, glues and adhesives and personal care products should provide some reduction in indoor VOCs.

Overall, substantial benefits in terms of toxic VOC reductions should result from implementing the plan.

VIII.3 Effectiveness in Reducing Emissions of Greenhouse Gases

Control measures that increase energy consumption such as flue gas emission control devices that require energy to build and operate, will increase CO_2 emissions. Those that involve combustion of VOC emissions such as incineration will put CO_2 into the atmosphere sooner, but won't significantly change the total loading of CO_2 to the atmosphere, since all

VOCs eventually oxidize to CO_2 anyway. Measures like better vehicle fuel economy, energy efficiency improvements, vapour recovery from gasoline marketing and distribution and reduction in solvent content of products will reduce CO_2 emissions.

CO_2 emission reductions from implementation of the plan have been estimated by totalling the reductions from the various energy efficiency measures and deducting the energy penalties associated with operating NO_x and VOC emission control tehcnologies on industry (1-3% of pre-control CO_2 emissions, depending on the technology). The estimated net CO_2 reduction is 6.0% below the total projected CO_2 emissions in Canada in 2005. This excludes any credit for fuel savings from refinery and gasoline distribution vapour controls, from reduction in solvent VOC emissions through product control or process changes, or from improved energy conversion efficiencies that might result from penetration of advanced combustion technologies such as Integrated Gasification Combined Cycle (IGCC).

VIII.4 Effectiveness in Meeting International Obligations

The international obligations of relevance to the plan are:

- basic obligations of an International Convention on Transboundary Air Pollution under the United Nations Economic Commission for Europe (ECE)
- a NO_x protocol under the ECE convention
- a pending VOC protocol under the ECE convention
- international commitments by Canada to take action to reduce CO_2 emissions and support development of an international convention on climate change.

Effectiveness of the plan in meeting each of these obligations is described below.

a) Convention on Tranboundary Air Pollution.

This convention, signed by Canada in 1979, commits nations to preventing pollution produced within their confines from harming neighbouring nations. It is interpreted by Canada in relation to NO_x and VOCs to mean that, as a minimum, there should be no increase in the transboundary flow of these pollutants from Canada to the United States into areas within the U.S. where NO_x and VOC related problems are already known to exist. To achieve this objective, Canada needs to ensure that no increase occurs in NO_x and VOC emissions in the Windsor - Quebec Corridor (WQC), the area from which most transboundary flow from Canada to the U.S. originates. The plan calls for a 30% reduction in NO_x and a 28% reduction in VOC emissions within the WQC, which will result in decreased flows of NO_x, VOCs and O_3 into the U.S.

b) ECE NO_x Protocol

The NO_x protocol, signed by Canada on October 31, 1988, calls for:

- a freeze in NO_x emissions at the 1987 level by December 31, 1994.

- national emission standards for major new mobile source categories and major new stationary sources and/or source categories based on "best available technology economically feasible".

- additional measures to reduce NO_x emissions from existing stationary sources taking into account age, utilization and other factors.

- commencing negotiations with neighbouring nations within 6 months after the protocol comes into force to establish measures and a time-table, by January 1, 1996, for further controls based on critical loads to the environment.

The plan meets the first three provisions and, in being designed with the objective of resolving NO_x- related environmental problems, will put Canada in a strong position for negotiating terms of the fourth provision

with the United States. Regarding the primary provision of a freeze in NO_x emissions at the 1987 level, Canadian NO_x emissions at the December 31, 1994 target date are projected to be about 5% below the 1987 level even without implementation of the plan.

c) ECE VOC Protocol

This protocol is currently under negotiation. The VOC control measures identified in the plan and the projected total reduction in VOC emissions of 20% nationally by 2005 will provide guidance in establishing a Canadian negotiating position for the protocol.

d) Commitment to Support Climate Change Control

Canada has led efforts to gain international agreement on measures to control global warming, including hosting of an International Conference on Climate Change in 1998 which called for a 20% reduction in CO_2 emissions by 2005.

Measures within the plan to reduce energy consumption are consistent with the anticipated thrust of a major Canadian program for reducing emissions of greenhouse gases, and with Canadian support for an international convention on climate change. The estimated net reduction in projected CO_2 emissions in 2005 of 7% or more through implementing the plan is only a small part of the 40% reduction in projected 2005 emissions that would be needed to bring CO_2 emissions 20% below the 1988 base year level. However, it is a first step and a solid demonstration of Canada's commitment to climate change control.

IX Plan Implementation

IX.1 Schedule

The schedule for implementing the plan initiatives is summarized in Tables 21 and 22.

The schedule illustrates that a major effort will be required in the next few years to put all elements of the plan in place. Some of the initiatives could be postponed to later years, but for many, especially new source performance standards, their effectiveness in reducing emissions in 2005 is much greater if they are implementation in the early 1990's.

The argument for not delaying retrofit programs any longer than necessary is that they are the primary means of achieving short-term improvements in air quality. When facilities are retrofitted, the results in terms of emissions reductions are felt immediately. This is in contrast to new source requirements where a primary objective is prevention of air quality deterioration and any resulting improvements to existing air quality depend on the rate of penetration of new facilities into the existing facility population.

TABLE 21 SCHEDULE FOR IMPLEMENTATION OF THE NO_x/VOC MANAGEMENT PLAN - NO_x REDUCTION INITIATIVES

Initiative		Control Instrument		
		Type	Delivery Date	Effective Date
(a) NATIONAL				
Energy Conservation and Product Control				
N101	Power utility DSM, energy perf. stds	DSM Plans	31 Dec. '93	2000/2005
N102	Energy efficiency in industry	Code or G.L.	92/93/93/95	1995-1998
N103	Energy audits by industry	Audit Plans	31 Dec. '92	1993
N104	Energy efficiency in buildings	CSA Standards	31 Dec. '94	1996
Consumer Choice and Lifestyle				
N201	Public Education - Driving/Alt. Transport	Media Campaign	91-99	1991-1999
N202	Public Education - Energy Conservation	Media Campaign	91-99	1991-1999
Source Control				
N301	Light Duty Vehicle NO_x limit - 0.4 g/mi	Federal Regulation	31 Dec. '91	1994/1996
N302	Heavy duty vehicle NO_x limits - 5/4 g/BHP-hr	Federal Regulation	31 Dec. '92	1995/2000
N303	Const. diesel engine NO_x limit - 6g/BHP-hr	Federal Regulation	31 Dec. '95	1998
N304	Cap on rail transport NO_x at 115 kt/yr	Reporting Schedule	31 Dec. '91	1992
N305	NSPS - Power plants	CEPA Guideline	31 Dec. '92	1995/2000
N306	NSPS - Industrial Boilers	CCME Guideline	31 Dec. '91	1994
N307	NSPS - Gas Turbines	CCME Guideline	30 June '92	1994
N308	NSPS - Compressor Engines	CCME Guideline	31 Dec. '91	1993
(b) REGIONAL (See Plan for Regional Application)				
Energy Conservation and Product Control				
N401	Urban Transportation Management	Management Plans	30 June '92	2000
Consumer Choice and Lifestyle				
N501	Restricted Activity Days	Mun. Plans/Criteria	31 Mar. '93	1993
N502	Highway speed reduction	Provincial Programs	31 Dec. '92	1993
N503	Public Education-Highway speeds	Prov. Media Campaign	92-99	1992-1999
Source Control				
N601	Motor Vehicle Inspection & Maintenance (I&M)	Provincial Programs	31 Dec. '93	1994
N602	Retrofit - Existing Power Plants	Prov. Limits/Schedules	31 Dec. '92	1997
N603	Retrofit - Existing Industrial Boilers	Prov. Limits/Schedules	31 Dec. '93	1997
N604	Retrofit - Existing Iron & Steel Mills	Prov. Limits/Schedules	31 Dec. '93	1997
N605	Retrofit - Existing Refinery Processes	CCME Guideline	31 Dec. '93	1997

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TABLE 22 SCHEDULE FOR IMPLEMENTATION OF THE NO_x/VOC MANAGEMENT PLAN - VOC REDUCTION INITIATIVES

Initiative		Control Instrument: Type	Delivery Date	Effective Date
(a) NATIONAL				
Energy Conservation and Product Control				
V101	Solvent Content of Paints	CCME Guideline	31 Dec. '92	1995/2000
V102	Interior Oil-Base Paints to Water-Base	CCME Guideline	31 Dec. '92	1997
V103	Solvent Content of Glues/Adhesives	CCME Guideline	31 Dec. '93	1997
V104	Summer Ban-auto Windshield Wash	CCME Request	1991	1991
V105	Solvent Content of Consumer Products	CCME Action Plan	31 Dec. '92	1993/1995
V106	Ozone Episode Ban-pesticide Appl^n	Municipal Bylaw	31 Dec. '92	1993
V107	Control for General Solvent Use	CCME Action Plan	31 Dec. '94	2000
Consumer Choice and Lifestyle				
V201	Public Education - Driving/Alt. Transport	Media Campaign	91-99	1991-1999
V202	Public Education - Energy Conservation	Media Campaign	91-99	1991-1999
Source Control				
V301	Light Duty Vehicle VOC Limit - 0.25 g/mi	Federal Regulation	31 Dec. '91	1994/1996
V302	Vapour Balance Equip. - New Gasoline Terminals	CCME Guideline/Code	31 Dec. '90/91	1992/1993
V303	Vapour Recovery Equip. - New Service Stations	CCME Code	31 Dec. '90	1992
V304	NSPS - Volatile Liquid Storage Tanks	CCME Guideline	31 Dec. '91	1993
V305	NSPS - Chemical Plant Processes	CCME Guideline	31 Dec. '92	1994
V306	NSPS - Plastics Processing	CCME Guideline	30 June '93	1995
V307	NSPS - Pulp & Paper Sulphate Process	CCME Guideline	31 Dec. '92	1994
V308	NSPS - Comm/Ind. Paint Application	CCME Guideline	31 Dec. '92	1994
V309	NSPS - Printing Ink Manufacturing	CCME Code	30 June '93	1994
V310	NSPS - Comm/Ind. Printing	CCME Code	30 June '93	1994
V311	NSPS - Comm/Ind. Degreasing	CCME Code	30 June '94	1995
V312	NSPS - Dry Cleaning	CCME Code	31 Dec. '93	1995
(b) REGIONAL (See Plan for Regional Application)				
Energy Conservation and Product Control				
N401	Urban Transportation Management	Management Plans	30 June '92	2000
Consumer Choice and Lifestyle				
V501	Restricted Activity Days	Mun. Plans/Criteria	31 Mar. '93	1993

VOC REDUCTION INITIATIVES (Cont'd)

Initiative		Control Instrument		
		Type	Delivery Date	Effective Date
Source Control				
V601	Motor Vehicle Inspection and Maintenance (I&M)	Provincial Programs	31 Dec. '93	1994
V602	Gasoline Volatility Limit-9.0 psi	Provincial Regulation	31 Dec. '91	1992
V603	Retrofit Vapor Bal. - Exist. Gas Terminals	CCME Code	31 Dec. '91	1993
V604	Retrofit Vapour Bal. - Existing Serv. Stations	CCME Code	31 Dec. '90	1993
V605	Vehicle Refuel Vapour Balance (Stage II)	CCME Code	31 Dec. '91	1993/1995
V606	Fugitive Emission Control - Refineries	CCME Code	31 Dec. '91	1993
V607	Retrofit - Chemical Plant Processes	Prov. Limits/Schedule	31 Dec. '92	1996
V608	Fugitive Emission Control - Chemical Plants	CCME Code	31 Dec. '91	1993
V609	Retrofit - Existing Plastics Processing	Prov. Limits/Schedule	30 June '93	1996
V610	Retrofit - Existing Pulp & Paper Sulphate Proc.	Prov. Limits/Schedule	31 Dec. '93	1997
V611	Retrofit - Existing Ink Manufacturing	Prov. Limits/Schedule	30 June '93	1996
V612	Retrofit - Existing Comm/Ind. Printing	Prov. Limits/Schedule	30 June '93	1996
V613	Retrofit - Existing Comm/Ind. Degreasing	Prov. Limits/Schedule	31 Dec. '93	1997
V614	Retrofit - Existing Dry Cleaning	Prov. Limits/Schedule	31 Dec. '93	1997
V615	Retrofit - Existing Wood Waste Burning	Prov. Limits/Schedule	31 Dec. '92	1991/1995

IX.2 Coordination

Some ongoing coordination of implementation initiatives, public education programs, status reporting and resource management will be required throughout the life of the plan.

This will be achieved through a permanent NO_x/VOC Consultation Office housed within Environment Canada but reporting to the CCME. The Office will consist of five persons, two of whom will be assigned to implement public education elements of the plan and manage communications functions associated with the plan.

IX.3 Mechanisms for Developing Specific Plan Initiatives

Almost all initiatives identified in the plan require followup work, usually through a multi-stakeholder consultation process, to develop the actual control instrument or program to a stage where it can be implemented by the specified jurisdiction.

Coordination of the stakeholder consultation groups or task forces will be left to the lead agency identified for each task. Prior to commencement the lead agency will prepare a brief proposal on the process that will be used, the schedule and the intended final product for approval by the CCME LRTAP Steering Committee. The lead agency will be responsible for progress reporting and, with the assistance of the NO_x/VOC Consultation Office, carrying the final product through to CCME approval and final publication.

IX.4 Evaluation and Reporting

The NO_x/VOC Consultation Office will develop a tracking system by which progress relative to the plan schedule can be easily monitored for all plan initiatives. This tracking system summary will be tabled at each meeting of the Federal/Provincial LRTAP Steering Committee (or other CCME committee that may be assigned to oversee implementation of the plan). It will also be readily available to all stakeholders at all times.

A brief annual progress report based on the tracking system and identifying problem areas (if any) and recommending corrective actions will be prepared by the NO_x/VOC Consultation Office for approval by the responsible CCME committee and submission to CCME in October of each year.

In the early years there will be little that can be done to evaluate the effectiveness of plan initiatives in improving air quality, since few of the initiatives will have actually been implemented long enough to establish any measurable trends. A simple tracking of emission reductions (using the streamlined inventory system recommended in the plan) and of ambient ozone monitoring data will be maintained during the early years. As well, a standardized method of reporting emission and air quality trends will be developed so that easy interpretation and year to year comparisons can be made. Summarized trend data will be included in the annual report to CCME. The report will also contain trend data for U.S. NO_x and VOC emissions in selected geographic regions of the U.S., and observations on the effect of these trends on the transboundary flow of NO_x, VOCs and O_3 into Canada.

IX.5 Resources

Government and industry stakeholders will cover their own costs for all task forces or work groups set up to develop specific control initiatives.

Also, governments and industry are expected to set up equitable cost sharing arrangements to conduct studies and investigations necessary to develop the control initiatives, asa well as specific studies and investigations identified for preparing a Second Edition of the plan in 1994.

CCME will approve a budget annually to fund participation of non-government organizations, public education and communications activities, editing and printing of control instruments and other plan related documents, and the travel and payroll of the NO_x/VOC Consultations Office.

X Cost of the Plan

The estimated cost of the plan is summarized in two categories.

(a) The cost to control NO_x and VOC emissions (presented as annual costs in Year 2005).

(b) The plan development and implementation costs exclusive of the "participation" costs that will be incurred by industry (presented as costs each year from 1991 to 1999).

These costs are presented in Tables 23, 24 and 25. The costs to control NO_x and VOC emissions (Tables 23 and 24) have been estimated by multiplying the $/tonne removal costs times the number of tonnes of pollutant reduction in year 2005. The $/tonne numbers encorporate both capital repayment and operating/maintenance costs. All costs are very approximate at this stage and should be used as a rough "order of magnitude" estimate of the cost implications of the plan to industry and other NO_x and VOC emitters.

The cost of the energy conservation and product control measures has been conservatively estimated as zero. Cost savings as high as $30 000/tonne may actually result from implementing some of these measures. More information is needed to refine the estimates for energy conservation and product control initiatives. In the interim they are listed as cost neutral.

The development and implementation costs (Table 25) include government human resource and study costs, and costs of non-government organization participation. They are based on the assumption that a typical regulatory initiative will take a minimum of 2 years, 4 person years by the lead agency, person year costs by 10 or more support agencies plus allowances for some study and miscellaneous costs (travel, printing, etc.).

Table 23 Cost of Achieving NO_x Emission Reductions Identified in the Management Plan

Initiative	Year 2005 Emission Reduction (T)	Reduction Cost (1989 $/T)	Year 2005 Annual Cost (1989 $X10^6)
NOx Control			
N101	38,800	0	0
N102	20,700	0	0
N103	-		
N104	3,700	0	0
N201	N.E.	N.E.	N.E.
N202	N.E.	N.E.	N.E.
N301	64,000	2 300	147.2
N302	20,900	N.E.	N.E.
N303	7,900	N.E.	N.E.
N304	-	-	-
N305	30,000	300	9.0
N306	35,900	500	18.0
N307	16,700	500	8.4
N308	14,500	3 500	50.8
N401	N.E.	N.E.	N.E.
N501	N.E.	N.E.	N.E.
N502	5,100	N.E	N.E.
N601	5,100	3 000	15.3
N602	58,000	500	29.0
N603	3,100	N.E.	N.E.
N604	N.E.	N.E.	N.E.
N605	N.E.	N.E.	N.E.
	324,400	857 (Avg.)	277.7

N.E. denotes "no estimate" at this time.

Table 24 Cost of Achieving VOC Emission Reductions Identified in the Management Plan

Initiative	Year 2005 Emission Reduction (T)	Reduction Cost (1989 $/T)	Year 2005 Annual Cost (1989 $X10^6)
V101	22,700	0	0
V102	13,000	0	0
V103	8,800	0	0
V104	14,000	0	0
V105	12,200	0	0
V106	0	0	0
V107	27,000	0	0
V201	N.E.	N.E.	N.E.
V202	N.E.	N.E.	N.E.
V301	16,300	2 300	37.5
V302	8,400	100	0.8
V303	6,700	170	1.1
V304	16,400	230	3.8
V305	23,000	410	9.4
V306	85,000	330	28.0
V307	N.E.	N.E.	N.E.
V308	24,700	2 000	49.4
V309	\[IN V310]		
V310	/5,900	2 000	11.8
V311	5,700	2 000	11.4
V312	2,300	2 000	4.6
V401	N.E.	N.E.	N.E.
V501	N.E.	N.E.	N.E.
V601	30,700	3 000	92.1
V602	49,100	1 000	49.1
V603	10,000	100	1.0
V604	11,100	170	1.9
V605	21,000	3 000	63.0
V606	15,800	410	6.5
V607	54,700	330	18.1
V608	5,600	1 540	8.6
V609	N.E.	N.E.	N.E.
V610	N.E.	N.E.	N.E.
V611	4,100	2 000	8.2
V612	4,100	2 000	8.2
V613	1,500	2 000	3.0
V614	1,900	2 000	3.8
V615	N.E.	N.E.	N.E.
	544,800	642 (Avg.)	349.9

N.E. denotes "no estimate" at this time.

Table 25 Plan Development and Implementation Costs

	Cost ($ x 1 000)					
	90/91	91/92	92/93	93/94	94/95	5-Year
1. NO_x Emission Control Initiatives						
a) National						
Energy Conservation	2 550	4 000	6 220	5 300	3 330	21 370
Consumer Choice	400	400	400	400	400	2 000
Source Control	700	800	600	600	690	3 390
Total National	3 650	5 200	7 220	6 300	4 390	26 760
b) Regional						
Energy Conservation	--	--	--	--	--	--
Consumer Choice	--	--	--	--	--	--
Source Control	500	1 000	1 200	800	850	4 350
Total Regional	500	1 000	1 200	800	850	4 350
Total NO_x Emission Control	4 150	6 200	8 420	7 100	5 240	31 110
2. VOC Emission Control Initiatives						
a) National						
Energy Conservation	500	1 000	2 100	1 200	770	5 570
Consumer Choice	400	400	400	400	400	2 000
Source Control	1 000	3 000	3 200	2 300	1 680	11 180
Total National	1 900	4 400	5 900	4 200	3 260	19 660
b) Regional						
Energy Conservation	--	--	--	--	--	--
Consumer Choice	--	--	--	--	--	--
Source Control	1 000	2 240	2 700	2 000	2 250	10 190
Total Regional	1 000	2 240	2 700	2 000	2 250	10 190
Total VOC Emission Control	2 900	6 640	8 600	6 200	5 510	29 850
3. Studies and Investigations for Second Edition of Plan						
a) Emission Inventories & Forecasts	1 320	1 570	920	820	770	5 400
b) Ambient Air Quality & Modelling	950	600	600	100	100	2 350
c) Technologies, Costs	2 410	2 210	1 610	1 510	1 510	9 250
d) U.S. Emission Control	220	110	50	140	140	660
Total Studies	4 900	4 490	3 180	2 570	2 520	17 660
4. Expanded Monitoring Network	1 000	2 000	2 000	1 000	1 000	7 000
5. Preparation of 2nd Edition of Plan			500	1 000	500	2 000
6. NO_x/VOC Consultation Office	600	600	600	600	600	3 000
Total Cost of Plan	13 550	19 930	23 300	18 470	15 370	90 620

XI Second Edition of the Plan

It is anticipated that adjustments will be needed to the plan to account for factors that are likely to change in the next few years. Some of these factors are:

- new emission forecasts projecting higher or lower emissions in future years than assumed in Forecast 90-A

- new technological innovations expanding the opportunities to reduce emissions and providing better cost effectiveness

- identified new concerns for the health and/or environmental effects of NO_x, VOCs and O_3

- new initiatives by the United States to control NO_x and VOC emissions and negotiating positions for including NO_x, VOCs and O_3 in a Transboundary Air Quality Agreement

- negotiations with the United States on further control measures for NO_x based on critical loads to the environment as per conditions of the ECE NO_x protocol

- final conditions of the ECE VOC protocol now under negotiation

- new information on source/receptor relationships obtained from oxidants modelling

- better information on emission sources and control options for some sectors

- the effect on NOx and VOC emissions of programs to control greenhouse gases.

Consultations with stakeholders will begin in the latter half of 1993 on the preparation of a Second Edition of the NO_x/VOC Management Plan, with a target date for completion of October, 1994.

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APPENDIX A

NO_x/VOC EMISSION FORECAST 90-A

NOx Emission Projections - Assumptions

A. Base Year: 1985

Sources of Data (base year):

- motor vehicles - population - Statistics Canada
  - Transportation Systems Division (TSD), Env. Canada
  - emission factors - TSD
    - new MOBILE4 data
  - vehicle miles travelled - TSD
- other transportation - fuel consumption - Statistics Canada
  - emission factors - U.S. EPA (AP-42)
    - Railway Assoc. of Canada (RAC)
- fuel combustion - fuel consumption - Statistics Canada
  - emission factors - U.S. EPA
  - petroleum refineries:
    - emissions - provided by refineries and provinces
    - fuel consumption - supplied by refineries and provinces
    - emission factors - U.S. EPA
  - natural gas processing:
    - emissions obtained directly from provincial agencies (also: fuel consumption)
- power generation - emissions - generally supplied by provincial utilities & power commissions (also includes fuel consumption)
  - additional emissions from small stations and gas turbines calculated from fuel consumption data and U.S. EPA emission factors
- industrial processes:
  - -emissions data from 1985 inventory
  - -data generated either through provincial agencies (point sources) or Statistics Canada production figures
- incineration/miscellaneous:
  - emissions calculated by use of Statistics Canada data with emission factors

B. Forecast Years: 1986-2005

Sources of data:

-motor vehicles
- emission factors - TSD
- growth in car/truck stock by fuel type
- National Energy Board (NEB) transportation model
- Motor Vehicle Manufacturers Assoc. (MVMA) sales forecasts
- assume no change in vehicle miles travelled

- other transportation
- growth in energy consumption (e.g. 1987 vs. 1985 values) - NEB
- province-specific statistics
- assume no change in emission factors or level of control technology available
- RAC projections of fuel demand and emissions in the rail sector

- fuel combustion
- industrial/commercial/residential
- growth in energy consumption (for each fuel) - NEB
- province-specific statistics
- assumes no change in emission factors or level of control technology available

- petroleum refineries (fuel combustion)
- growth in energy demand (petroleum products)- NEB
- no changes in emission factors or level of control technology

- natural gas processing (fuel combustion)
- Informetrica GDP growth rates for "Petroleum & gas-resource extraction"
- assumes decrease in NOx emissions in Alberta at a rate of 3%/year starting in 1991 (45% by the year 2005)

- power generation
- emissions forecasts obtained from various provincial utilities and from Oil, Gas & Energy Division, Env. Canada simulation model (CANSIM)

- Industrial processes
  - Informetrica GDP growth rates used for following sectors:

    *nitric acid - "Chemicals"
    *nitrate fertilizer - "Chemicals"
    *metallurgical coke - "Petroleum & coal products - manufacturing"
    *aluminum production - "Primary metals"
    *sulphate pulping - "Pulp & paper"
    *tar sands - "Mining services"
    -data for growth rates are province-specific

  - petroleum refineries- growth in energy demand (petroleum products)- NEB

- incineration/miscellaneous
  - population growth rates for growth in incineration practices
  - wigwam burners - Informetrica GDP growth rates-"Wood manufacturing"
  - slash burning - Informetrica GDP growth rates -"Forestry"

Note: All growth rates are for a "high growth" scenario as forecast by the NEB (1988). Informetrica growth rates are based on the most recent tabulations from their economic model (TIM).

A. Sheffield
February 28, 1990

NO_x/VOC EMISSION FORECAST 90-A

NITROGEN OXIDE (NO_x)

PROVINCE: Canada

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	352.0	250.4	169.0	145.4	149.8
Light-Duty Trucks					
Gas	95.4	86.4	78.7	74.9	77.5
Diesel	5.7	6.9	6.9	8.7	10.9
Heavy-Duty Trucks					
Gas	20.9	13.5	8.0	6.3	6.8
Diesel	264.3	322.0	241.2	230.3	254.0
Off-Road Diesel					
Construction	31.3	32.0	36.0	41.7	49.4
Agriculture	53.5	64.8	70.2	74.8	81.0
Railroads	132.1	113.2	114.0	113.0	113.0
Other	145.6	149.7	168.0	180.1	187.0
Other	79.4	82.7	84.0	86.2	90.6
Fuel Combustion					
Residential	41.5	37.3	37.2	37.2	36.9
Commercial	25.8	25.9	27.3	27.8	28.4
Industrial					
Natural Gas	158.8	155.3	152.5	136.0	112.5
Other	119.4	131.8	150.5	163.7	178.9
Power Generation	247.9	287.7	319.2	363.9	351.7
Industrial Processes	89.0	89.9	104.0	119.8	139.7
Incineration/Miscellaneous	24.3	27.2	29.2	31.9	34.6
T O T A L	1886.9	1876.7	1795.9	1841.7	1902.7

NO_x/VOC EMISSION FORECAST 90-A

NITROGEN OXIDE (NO_x)

PROVINCE: Newfoundland

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	4.9	3.1	1.9	1.7	1.8
Light-Duty Trucks					
Gas	2.1	1.8	1.6	1.5	1.6
Diesel	0.1	0.1	0.1	0.2	0.2
Heavy-Duty Trucks					
Gas	0.7	0.4	0.2	0.1	0.1
Diesel	5.6	7.9	6.6	6.5	7.1
Off-Road Diesel					
Construction	0.4	0.2	0.4	0.4	0.4
Agriculture	0.1	0.1	0.1	0.1	0.2
Railroads	0.8	-	-	-	-
Other	5.8	6.0	6.9	7.7	8.2
Other	2.6	3.0	3.0	3.1	3.2
Fuel Combustion					
Residential	0.8	0.8	0.8	0.8	0.8
Commercial	0.4	0.4	0.3	0.3	0.3
Industrial					
Natural Gas	-	-	-	-	-
Other	2.4	3.2	3.3	3.7	4.3
Power Generation	5.3	6.0	5.6	5.8	5.8
Industrial Processes	1.3	1.3	1.6	1.7	1.7
Incineration/Miscellaneous	0.4	0.4	0.5	0.5	0.5
T O T A L	33.7	34.7	32.9	34.1	36.2

NO_x/VOC EMISSION FORECAST 90-A NITROGEN OXIDE (NO_x)

PROVINCE: Prince Edward Island **KILOTONNES (as NO_2)**

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	1.6	1.0	0.6	0.6	0.6
Light-Duty Trucks					
Gas	0.5	0.5	0.4	0.4	0.4
Diesel	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Heavy-Duty Trucks					
Gas	0.2	0.1	0.1	< 0.1	< 0.1
Diesel	1.5	2.1	1.8	1.7	1.9
Off-Road Diesel					
Construction	0.1	0.1	0.2	0.2	0.2
Agriculture	0.3	0.4	0.5	0.6	0.6
Railroads	0.1	0.2	0.1	0.1	0.1
Other	0.3	0.3	0.4	0.4	0.4
Other	0.3	0.3	0.3	0.3	0.3
Fuel Combustion					
Residential	0.4	0.4	0.4	0.4	0.4
Commercial	0.1	0.1	0.1	0.1	0.1
Industrial					
Natural Gas	-	-	-	-	-
Other	< 0.1	< 0.1	< 0.1	< 0.1	0.1
Power Generation	0.1	0.1	0.1	0.1	0.1
Industrial Processes	-	-	-	-	-
Incineration/Miscellaneous	0.1	0.1	0.1	0.1	0.1
T O T A L	5.6	5.7	5.1	5.0	5.4

NO_x/VOC EMISSION FORECAST 90-A

NITROGEN OXIDE (NO_x)

PROVINCE: Nova Scotia

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	10.6	6.8	4.2	3.7	3.9
Light-Duty Trucks					
Gas	4.0	3.4	3.1	2.9	3.0
Diesel	0.2	0.3	0.3	0.3	0.4
Heavy-Duty Trucks					
Gas	1.1	0.6	0.3	0.2	0.2
Diesel	12.8	18.2	15.2	14.9	16.4
Off-Road Diesel					
Construction	0.7	0.6	0.6	0.7	0.8
Agriculture	0.7	1.0	1.2	1.4	1.6
Railroads	4.1	5.2	5.2	5.2	5.2
Other	8.3	8.4	9.8	10.9	11.6
Other	2.1	2.4	2.5	2.5	2.6
Fuel Combustion					
Residential	1.8	1.8	1.7	1.6	1.6
Commercial	1.2	1.0	0.9	0.9	0.8
Industrial					
Natural Gas	-	-	-	-	-
Other	2.9	3.4	3.6	4.0	4.6
Power Generation	21.7	25.2	26.7	26.8	27.1
Industrial Processes	1.6	1.7	1.8	2.0	2.1
Incineration/Miscellaneous	0.5	0.7	0.7	0.8	0.9
T O T A L	74.3	80.7	77.8	78.8	82.8

NO_x/VOC EMISSION FORECAST 90-A

NITROGEN OXIDE (NO_x)

PROVINCE: New Brunswick

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	8.3	5.3	3.3	2.9	3.0
Light-Duty Trucks					
Gas	3.3	2.8	2.5	2.4	2.4
Diesel	0.2	0.2	0.2	0.3	0.3
Heavy-Duty Trucks					
Gas	0.9	0.5	0.2	0.2	0.1
Diesel	8.8	12.5	10.4	10.3	11.3
Off-Road Diesel					
Construction	0.5	0.6	0.6	0.6	0.7
Agriculture	0.5	0.7	0.9	1.0	1.2
Railroads	2.4	3.1	3.1	3.1	3.1
Other	3.5	3.6	4.1	4.6	4.9
Other	0.8	0.8	0.8	0.8	0.9
Fuel Combustion					
Residential	1.0	1.0	1.0	1.0	1.0
Commercial	0.6	0.5	0.5	0.5	0.4
Industrial					
Natural Gas	-	-	-	-	-
Other	3.9	4.8	5.0	5.5	6.3
Power Generation	7.9	22.7	31.6	36.7	39.2
Industrial Processes	2.7	3.1	3.4	3.7	4.0
Incineration/Miscellaneous	1.1	1.5	1.6	1.8	1.9
T O T A L	46.4	63.7	69.2	75.4	80.7

NO_x/VOC EMISSION FORECAST 90-A

NITROGEN OXIDE (NO_x)

PROVINCE: Quebec

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	72.6	50.3	32.7	30.5	32.4
Light-Duty Trucks					
Gas	8.5	11.0	10.8	10.4	10.6
Diesel	0.5	0.6	0.6	0.7	0.9
Heavy-Duty Trucks					
Gas	3.1	2.1	1.1	0.9	0.9
Diesel	28.7	47.9	37.1	35.9	39.1
Off-Road Diesel					
Construction	3.6	4.3	4.9	5.2	5.5
Agriculture	4.4	5.4	5.8	6.2	6.7
Railroads	16.9	11.5	11.6	11.4	11.4
Other	21.1	24.6	26.3	27.5	28.1
Other	16.4	17.3	17.9	18.6	19.9
Fuel Combustion					
Residential	7.5	6.1	5.3	4.5	4.1
Commercial	3.9	4.7	4.7	4.6	4.6
Industrial					
Natural Gas	-	-	-	-	-
Other	21.3	24.6	26.0	28.0	29.4
Power Generation	1.5	1.9	3.3	3.3	3.3
Industrial Processes	6.8	7.8	8.8	10.0	11.3
Incineration/Miscellaneous	6.0	7.3	8.2	9.0	10.1
T O T A L	222.8	227.4	205.1	206.7	218.3

NO_x/VOC EMISSION FORECAST 90-A

NITROGEN OXIDE (NO_x)

PROVINCE: Ontario

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	134.4	95.3	65.0	56.7	59.6
Light-Duty Trucks					
Gas	33.0	32.4	32.6	31.9	33.4
Diesel	2.3	2.8	2.8	3.5	4.5
Heavy-Duty Trucks					
Gas	2.0	1.2	0.7	0.7	0.7
Diesel	82.6	102.4	78.7	75.8	83.2
Off-Road Diesel					
Construction	9.1	10.9	13.7	17.1	21.5
Agriculture	7.4	7.5	8.0	8.2	8.6
Railroads	30.3	26.0	26.3	26.0	26.0
Other	27.2	31.7	34.7	34.9	34.3
Other	20.2	22.0	23.1	23.7	24.4
Fuel Combustion					
Residential	15.4	14.6	15.0	15.4	15.3
Commercial	9.7	9.5	10.4	10.5	11.0
Industrial					
Natural Gas	0.5	0.5	0.6	0.6	0.6
Other	45.1	50.1	58.2	63.7	70.5
Power Generation	97.6	74.9	83.4	114.6	94.8
Industrial Processes	38.2	40.5	47.6	54.2	62.3
Incineration/Miscellaneous	2.5	2.7	2.8	2.9	2.9
T O T A L	557.5	525.0	503.6	540.4	553.6

NO_x/VOC EMISSION FORECAST 90-A

NITROGEN OXIDE (NO_x)

PROVINCE: Manitoba

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	17.1	12.7	8.7	7.1	6.9
Light-Duty Trucks					
Gas	6.1	4.8	4.0	3.7	3.9
Diesel	0.3	0.4	0.4	0.5	0.6
Heavy-Duty Trucks					
Gas	1.7	1.1	0.7	0.5	0.5
Diesel	16.2	21.1	17.2	17.4	20.2
Off-Road Diesel					
Construction	1.4	1.9	1.9	2.2	2.6
Agriculture	5.2	6.1	7.0	7.0	7.2
Railroads	17.2	15.4	15.5	15.4	15.4
Other	3.7	5.7	6.3	6.6	7.0
Other	4.3	4.3	4.3	4.4	4.6
Fuel Combustion					
Residential	1.5	1.3	1.3	1.3	1.3
Commercial	1.3	1.2	1.3	1.4	1.4
Industrial					
Natural Gas	-	-	-	-	-
Other	2.2	2.2	2.5	2.8	3.3
Power Generation	2.7	1.6	1.6	0.7	0.7
Industrial Processes	0.6	0.6	0.7	0.8	0.9
Incineration/Miscellaneous	0.4	0.4	0.4	0.5	0.5
T O T A L	81.9	80.8	73.8	72.3	77.0

NO_x/VOC EMISSION FORECAST 90-A

NITROGEN OXIDE (NO_x)

PROVINCE: Saskatchewan

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	13.1	10.8	7.6	6.1	6.4
Light-Duty Trucks					
Gas	8.7	5.6	4.3	4.0	4.1
Diesel	0.4	0.6	0.6	0.7	0.9
Heavy-Duty Trucks					
Gas	2.7	1.6	0.9	0.7	0.8
Diesel	24.1	24.1	18.3	18.3	22.0
Off-Road Diesel					
Construction	2.6	2.5	2.6	2.9	3.4
Agriculture	14.9	17.6	19.0	21.0	23.5
Railroads	9.6	6.9	6.9	6.9	6.9
Other	7.4	8.5	9.6	10.3	10.4
Other	9.5	8.6	8.1	8.1	8.7
Fuel Combustion					
Residential	2.3	2.0	2.1	2.2	2.2
Commercial	1.1	1.1	1.3	1.4	1.5
Industrial					
Natural Gas	16.9	19.6	21.5	22.2	22.1
Other	4.8	4.5	5.1	5.8	6.4
Power Generation	36.1	43.6	47.8	45.6	44.0
Industrial Processes	0.9	1.0	1.1	1.2	1.4
Incineration/Miscellaneous	0.5	0.6	0.7	0.8	0.8
T O T A L	155.6	159.2	157.5	158.2	165.5

NO_x/VOC EMISSION FORECAST 90-A

NITROGEN OXIDE (NO_x)

PROVINCE: Alberta

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	42.3	27.2	18.6	15.5	15.6
Light-Duty Trucks					
Gas	11.2	10.9	8.5	7.7	7.8
Diesel	0.6	0.7	0.7	0.9	1.1
Heavy-Duty Trucks					
Gas	3.5	2.9	1.8	1.5	1.8
Diesel	33.5	39.5	24.7	21.4	22.7
Off-Road Diesel					
Construction	8.1	6.3	6.4	7.4	8.8
Agriculture	17.1	20.6	21.1	22.3	24.0
Railroads	33.8	31.4	31.7	31.4	31.4
Other	25.2	21.9	26.0	29.5	30.9
Other	14.9	13.8	13.5	13.9	14.5
Fuel Combustion					
Residential	7.0	5.9	6.2	6.5	6.6
Commercial	4.5	4.5	4.8	5.1	5.2
Industrial					
Natural Gas	131.5	124.9	118.4	100.3	76.7
Other	11.3	13.8	18.0	18.4	19.0
Power Generation	68.1	106.3	112.7	122.4	127.0
Industrial Processes	26.2	21.8	25.6	31.3	39.3
Incineration/Miscellaneous	1.5	2.4	2.6	2.9	3.2
T O T A L	440.3	454.8	441.3	438.4	435.6

NO_x/VOC EMISSION FORECAST 90-A

NITROGEN OXIDE (NO_x)

PROVINCE: British Columbia

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	46.6	37.5	26.1	20.4	19.4
Light-Duty Trucks					
Gas	17.3	12.7	10.5	9.6	9.9
Diesel	0.9	1.2	1.2	1.5	1.8
Heavy-Duty Trucks					
Gas	4.8	2.9	1.9	1.6	1.6
Diesel	48.2	44.2	29.8	26.8	28.7
Off-Road Diesel					
Construction	4.0	3.7	3.7	3.9	4.2
Agriculture	2.9	5.3	6.5	6.9	7.3
Railroads	16.8	13.4	13.5	13.4	13.4
Other	37.2	33.7	37.9	41.2	44.2
Other	6.7	8.2	8.4	8.6	9.2
Fuel Combustion					
Residential	3.6	3.2	3.2	3.3	3.3
Commercial	2.7	2.6	2.8	2.8	2.9
Industrial					
Natural Gas	9.9	10.3	12.0	12.9	13.1
Other	25.3	25.1	28.7	31.6	34.8
Power Generation	3.7	1.0	1.0	1.0	1.2
Industrial Processes	10.7	12.1	13.4	14.9	16.7
Incineration/Miscellaneous	11.3	11.1	11.6	12.6	13.7
T O T A L	252.6	228.2	212.2	213.0	225.4

NO_x/VOC EMISSION FORECAST 90-A

NITROGEN OXIDE (NO_x)

PROVINCE: Yukon/North West Territories

KILOTONNES (as NO_2)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	0.5	0.4	0.3	0.2	0.2
Light-Duty Trucks					
Gas	0.7	0.5	0.4	0.4	0.4
Diesel	< 0.1	< 0.1	< 0.1	0.1	0.1
Heavy-Duty Trucks					
Gas	0.2	0.1	0.1	0.1	0.1
Diesel	2.3	2.1	1.4	1.3	1.4
Off-Road Diesel					
Construction	0.8	0.9	1.0	1.1	1.3
Agriculture	< 0.1	0.1	0.1	0.1	0.1
Railroads	0.1	0.1	0.1	0.1	0.1
Other	5.9	5.3	6.0	6.5	7.0
Other	1.6	2.0	2.1	2.2	2.3
Fuel Combustion					
Residential	0.2	0.2	0.2	0.2	0.2
Commercial	0.3	0.3	0.2	0.2	0.2
Industrial					
Natural Gas	-	-	-	-	-
Other	0.2	0.1	0.1	0.2	0.2
Power Generation	3.2	4.4	5.4	6.9	8.5
Industrial Processes	-	-	-	-	-
Incineration/Miscellaneous	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
T O T A L	16.0	16.6	17.5	19.6	22.1

VOC Emission Projections - Assumptions

A. Base Year: 1985

Sources of Data (base year):

- motor vehicles - population - Statistics Canada
  - Transportation Systems Division (TSD), Env. Canada
  - emission factors - TSD
    - new MOBILE4 data
  - vehicle miles travelled - TSD
- other transportation - fuel consumption - Statistics Canada
  - emission factors - U.S. EPA (AP-42)
    - Railway Assoc. of Canada (RAC)
- fuel combustion - fuel consumption - Statistics Canada
  - emission factors - U.S. EPA
  - petroleum refineries:
    - emissions - provided by refineries and provinces
    - fuel consumption - supplied by refineries and provinces
    - emission factors - U.S. EPA
  - natural gas processing:
    - emissions calculated using emission factors from U.S. EPA and fuel consumption from provincial agencies
- power generation - emissions - fuel consumption from major plants (provincial utilities) used with U.S. EPA emission factors
  - additional emissions from small stations and gas turbines calculated from fuel consumption data and U.S. EPA emission factors
- industrial processes:
  - emissions data from 1985 inventory
  - petroleum refinery emission data based on PACE statistics + provincial information

- petrochemical industry emissions obtained from internal Env. Canada report
- plastics industry emissions data and emission factors provided by the Environment and Plastics Institute of Canada (EPIC)
- data generated either through provincial agencies (point sources) or Statistics Canada production figures

- incineration/miscellaneous:
  - 1985 emissions data
    - emissions calculated by use of Statistics Canada data with emission factors
  - emission estimates from the use of solvents obtained from consultants

B. Forecast Years: 1986-2005

Sources of data:

-motor vehicles
- emission factors - TSD
- growth in car/truck stock by fuel type
- National Energy Board (NEB) transportation model
- Motor Vehicle Manufacturers Assoc. (MVMA) sales forecasts
- assumes no change in vehicle miles travelled

- other transportation
  - growth in energy consumption (e.g. 1987 vs. 1985 values) - NEB
  - province-specific statistics
  - assumes no change in emission factors or level of control technology available
  - RAC projections of fuel demand and emissions in the rail sector

- fuel combustion
  - industrial/commercial/residential
  - growth in energy consumption (for each fuel) - NEB
  - province-specific statistics
  - assumes no change in emission factors or level of control technology available

- petroleum refineries (fuel combustion)
  - growth in energy demand petroleum products)- NEB
  - no changes in emission factors or level of control technology

- natural gas processing (fuel combustion)
  - Informetrica GDP growth rates for "Petroleum & gas-resource extraction"
  - assumes no changes in emission factors or level of control technology

- power generation
  - emissions assumed to be constant throughout forecast period

- Industrial processes
  - Informetrica GDP growth rates used for following sectors:

    *bakeries - "Food and Beverage"
    *petrochemicals - "Chemicals"
    *metallurgical coke - "Petroleum & coal products - manufacturing"
    *aluminum production - "Primary metals"
    *sulphate pulping - "Pulp & paper"
    *tar sands - "Mining services"
    *crude oil production - "Petroleum and gas - resource extraction"
    *coal industry - "coal resource extraction"
    *carbon black - "Chemicals"
    *pulpboard manufacture - "Wood-manufacture"
    *plywood/veneer - "Wood-manufacture"
    -data for growth rates are province-specific

  - petroleum refineries- growth in energy demand (petroleum products) - NEB

  - plastics- growth rates obtained from the EPIC (not province-specific)

- incineration/miscellaneous
  - population growth rates for growth in incineration practices
  - wigwam burners - Informetrica GDP growth rates-"Wood manufacturing"
  - slash burning - Informetrica GDP growth rates -"Forestry"
  - gasoline marketing - NEB (1988) forecasts in motor gasoline consumption
  - structural fires - Informetrica growth for "households"
  - solvent use - Statistics Canada growth in "population"
  - surface coatings - Informetrica growth for "households"
  - dry cleaning - Statistics Canada growth in "population"

Note: All growth rates are for a "high growth" scenario as forecast by the NEB. Informetrica growth rates are based on their most recent tabulations from their economic model (TIM).

A. Sheffield
February 28, 1990

NO_x/VOC EMISSION FORECAST 90-A

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: Canada

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	412.7	334.0	256.1	229.4	237.3
Light-Duty Trucks					
Gas	142.7	127.9	113.7	104.8	108.9
Diesel	1.4	2.1	2.1	2.9	3.7
Heavy-Duty Trucks					
Gas	25.1	9.9	5.5	4.2	4.3
Diesel	28.7	30.4	33.4	37.7	43.5
Off-Road Gasoline	66.1	64.8	66.5	70.3	74.3
Other	72.6	76.1	79.5	82.8	89.0
Fuel Combustion					
Fuelwood	107.7	111.8	119.3	128.5	132.7
Residential/Commercial	3.7	3.5	3.5	3.5	3.5
Industrial	49.5	46.0	52.1	57.3	63.9
Industrial Processes					
Petrochemicals	107.8	114.4	134.4	165.2	206.8
Petroleum Refining	40.3	42.7	44.4	46.5	49.3
Plastics	13.6	16.0	20.9	25.6	29.4
Crude Oil	15.0	14.9	18.2	26.2	28.3
Other	46.7	51.2	62.1	71.1	81.1
Incineration/Miscellaneous					
Surface Coatings	187.5	207.5	223.9	238.7	253.6
Fuel Marketing	109.0	109.0	113.7	119.1	124.4
Dry Cleaning	14.0	14.5	15.0	15.3	15.5
Solvent Use	300.5	314.0	323.6	329.9	333.8
Slash Burning	80.6	89.8	101.7	113.6	129.0
Other	25.6	25.7	28.0	29.7	32.4
Power Generation	2.7	2.7	2.7	2.7	2.7
T O T A L	1853.5	1808.9	1820.3	1905.0	2047.4

NO_x/VOC EMISSION FORECAST 90-A

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: Newfoundland

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	5.1	3.7	2.5	2.3	2.4
Light-Duty Trucks					
Gas	2.8	2.4	2.1	1.9	2.0
Diesel	< 0.1	< 0.1	< 0.1	0.1	0.1
Heavy-Duty Trucks					
Gas	0.7	0.2	0.1	0.1	0.1
Diesel	0.6	0.8	0.9	1.1	1.2
Off-Road Gasoline	2.7	2.9	3.1	3.5	3.8
Other	2.3	2.4	2.6	2.7	2.8
Fuel Combustion					
Fuelwood	8.7	8.7	9.1	9.4	9.8
Residential/Commercial	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Industrial	< 0.1	0.1	0.1	0.1	0.1
Industrial Processes					
Petrochemicals	-	-	-	-	-
Petroleum Refining	-	-	-	-	-
Plastics	< 0.1	< 0.1	< 0.1	< 0.1	0.1
Crude Oil	-	-	1.7	9.0	11.0
Other	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Incineration/Miscellaneous					
Surface Coatings	2.8	3.0	3.3	3.4	3.5
Fuel Marketing	1.9	1.9	2.0	2.0	2.1
Dry Cleaning	0.3	0.3	0.3	0.4	0.4
Solvent Use	6.0	6.4	6.7	7.0	7.2
Slash Burning	1.4	1.7	1.8	2.0	2.5
Other	0.1	0.1	0.1	0.1	0.1
Power Generation	0.2	0.2	0.2	0.2	0.2
T O T A L	35.6	34.7	36.5	45.2	49.3

NO_x/VOC EMISSION FORECAST 90-A

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: Prince Edward Island

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	1.7	1.3	0.9	0.8	0.9
Light-Duty Trucks					
Gas	0.7	0.6	0.6	0.5	0.5
Diesel	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Heavy-Duty Trucks					
Gas	0.2	0.1	< 0.1	< 0.1	< 0.1
Diesel	0.2	0.2	0.2	0.3	0.3
Off-Road Gasoline	0.2	0.2	0.2	0.2	0.2
Other	0.1	0.2	0.2	0.2	0.2
Fuel Combustion					
Fuelwood	4.5	4.5	4.7	4.9	5.0
Residential/Commercial	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Industrial	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Industrial Processes					
Petrochemicals	-	-	-	-	-
Petroleum Refining	-	-	-	-	-
Plastics	-	-	-	-	-
Crude Oil	-	-	-	-	-
Other	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Incineration/Miscellaneous					
Surface Coatings	1.1	1.2	1.2	1.2	1.3
Fuel Marketing	0.6	0.6	0.6	0.6	0.7
Dry Cleaning	0.1	0.1	0.1	0.1	0.1
Solvent Use	1.3	1.4	1.4	1.5	1.5
Slash Burning	0.2	0.3	0.3	0.3	0.4
Other	0.1	0.1	0.1	0.1	0.1
Power Generation	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
T O T A L	11.0	10.8	10.5	10.7	11.2

NO_x/VOC EMISSION FORECAST 90-A

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: Nova Scotia

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	11.3	8.4	6.1	5.5	5.7
Light-Duty Trucks					
Gas	5.5	4.7	4.1	3.8	3.9
Diesel	0.1	0.1	0.1	0.1	0.1
Heavy-Duty Trucks					
Gas	1.2	0.4	0.2	0.1	0.1
Diesel	1.4	1.7	2.1	2.4	2.8
Off-Road Gasoline	0.9	0.9	0.9	1.0	1.1
Other	2.1	2.3	2.5	2.6	3.0
Fuel Combustion					
Fuelwood	4.6	4.6	4.8	5.0	5.2
Residential/Commercial	0.3	0.3	0.3	0.3	0.3
Industrial	< 0.1	< 0.1	< 0.1	< 0.1	0.1
Industrial Processes					
Petrochemicals	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Petroleum Refining	3.2	3.5	3.6	3.8	4.1
Plastics	0.1	0.1	0.1	0.2	0.2
Crude Oil	0.7	0.5	0.2	0.1	0.1
Other	0.2	0.3	0.3	0.3	0.4
Incineration/Miscellaneous					
Surface Coatings	4.6	5.0	5.2	5.3	5.4
Fuel Marketing	3.7	3.8	3.9	4.0	4.2
Dry Cleaning	0.5	0.5	0.5	0.5	0.5
Solvent Use	9.3	9.6	9.8	10.0	10.1
Slash Burning	2.0	2.6	2.9	3.1	3.4
Other	0.4	0.4	0.4	0.4	0.5
Power Generation	0.1	0.1	0.1	0.1	0.1
T O T A L	52.2	49.8	48.1	48.6	51.3

NO_x/VOC EMISSION FORECAST 90-A

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: New Brunswick

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	8.9	6.6	4.7	4.2	4.3
Light-Duty Trucks					
Gas	4.5	3.9	3.4	3.1	3.2
Diesel	< 0.1	0.1	0.1	0.1	0.1
Heavy-Duty Trucks					
Gas	1.0	0.3	0.1	0.1	0.1
Diesel	1.0	1.2	1.5	1.7	1.9
Off-Road Gasoline	0.8	0.8	0.8	0.9	0.9
Other	1.4	1.6	1.6	1.7	2.0
Fuel Combustion					
Fuelwood	5.3	5.2	5.5	5.7	5.9
Residential/Commercial	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Industrial	< 0.1	0.1	0.1	0.1	0.1
Industrial Processes					
Petrochemicals	-	-	-	-	-
Petroleum Refining	1.3	1.4	1.4	1.5	1.6
Plastics	0.1	0.2	0.2	0.3	0.3
Crude Oil	0.5	0.5	0.6	0.6	0.6
Other	0.6	0.7	0.8	0.9	1.0
Incineration/Miscellaneous					
Surface Coatings	3.8	4.1	4.3	4.4	4.4
Fuel Marketing	3.2	3.3	3.4	3.5	3.7
Dry Cleaning	0.4	0.4	0.4	0.4	0.5
Solvent Use	7.5	7.8	8.1	8.3	8.5
Slash Burning	4.5	6.3	7.0	7.6	8.1
Other	0.5	0.5	0.6	0.6	0.6
Power Generation	0.1	0.1	0.1	0.1	0.1
T O T A L	45.4	45.1	44.7	45.8	47.9

NO_x/VOC EMISSION FORECAST 90-A

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: Quebec

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	81.9	63.3	46.3	44.0	46.2
Light-Duty Trucks					
Gas	12.2	15.1	14.5	13.4	13.7
Diesel	0.1	0.2	0.2	0.2	0.3
Heavy-Duty Trucks					
Gas	3.6	1.5	0.7	0.5	0.5
Diesel	3.1	4.5	5.2	5.9	6.7
Off-Road Gasoline	4.8	5.0	5.5	5.9	6.4
Other	10.4	10.6	11.1	11.7	12.6
Fuel Combustion					
Fuelwood	39.9	46.7	50.0	51.5	53.5
Residential/Commercial	0.4	0.4	0.4	0.3	0.3
Industrial	0.3	0.3	0.4	0.4	0.4
Industrial Processes					
Petrochemicals	22.2	24.6	27.4	31.5	36.4
Petroleum Refining	7.1	7.5	7.7	8.0	8.4
Plastics	3.5	4.1	5.4	6.6	7.6
Crude Oil	0.7	0.6	0.6	0.6	0.6
Other	8.3	9.1	10.3	11.3	12.7
Incineration/Miscellaneous					
Surface Coatings	48.5	53.9	57.3	60.1	62.5
Fuel Marketing	23.3	23.3	24.9	26.3	27.2
Dry Cleaning	3.6	3.7	3.8	3.8	3.8
Solvent Use	69.1	70.8	72.0	72.3	72.2
Slash Burning	20.2	26.2	30.0	33.9	38.7
Other	8.8	9.2	9.7	10.0	10.5
Power Generation	0.1	0.1	0.1	0.1	0.1
T O T A L	372.1	380.7	383.5	398.3	421.3

NO_x/VOC EMISSION FORECAST 90-A

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: Ontario

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	154.9	129.4	101.3	92.5	97.6
Light-Duty Trucks					
Gas	50.8	50.1	49.1	46.8	49.2
Diesel	0.6	0.8	0.8	1.2	1.6
Heavy-Duty Trucks					
Gas	2.3	0.9	0.6	0.4	0.4
Diesel	8.9	9.6	10.9	12.4	14.3
Off-Road Gasoline	19.4	20.6	22.7	24.2	25.4
Other	21.6	23.1	23.5	23.5	24.3
Fuel Combustion					
Fuelwood	33.9	31.2	33.8	40.4	41.4
Residential/Commercial	1.1	1.1	1.2	1.2	1.3
Industrial	1.1	1.1	1.3	1.4	1.5
Industrial Processes					
Petrochemicals	39.6	42.0	47.2	54.4	62.7
Petroleum Refining	15.4	16.7	18.1	19.1	20.2
Plastics	8.1	9.4	12.4	15.1	17.4
Crude Oil	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Other	30.4	32.7	39.2	45.6	53.3
Incineration/Miscellaneous					
Surface Coatings	83.3	94.6	105.5	116.2	127.0
Fuel Marketing	41.6	44.3	48.8	51.9	54.6
Dry Cleaning	5.0	5.3	5.5	5.6	5.7
Solvent Use	129.6	136.9	141.8	145.2	147.2
Slash Burning	0.5	0.6	0.7	0.8	1.0
Other	4.2	4.6	5.1	5.5	6.0
Power Generation	0.4	0.4	0.4	0.4	0.4
T O T A L	652.7	655.4	669.9	703.8	752.5

NO_x/VOC EMISSION FORECAST 90-A

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: Manitoba

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	22.2	18.5	14.2	11.8	11.5
Light-Duty Trucks					
Gas	9.3	7.3	6.0	5.4	5.6
Diesel	0.1	0.1	0.1	0.2	0.2
Heavy-Duty Trucks					
Gas	1.9	0.8	0.5	0.3	0.3
Diesel	1.8	2.0	2.4	2.8	3.5
Off-Road Gasoline	4.6	4.3	4.3	4.4	4.7
Other	3.9	4.2	4.3	4.6	4.9
Fuel Combustion					
Fuelwood	1.9	1.5	1.5	1.4	1.3
Residential/Commercial	0.3	0.3	0.2	0.2	0.2
Industrial	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Industrial Processes					
Petrochemicals	-	-	-	-	-
Petroleum Refining	-	-	-	-	-
Plastics	0.3	0.4	0.5	0.6	0.7
Crude Oil	0.1	0.1	0.2	0.2	0.1
Other	0.3	0.3	0.4	0.4	0.4
Incineration/Miscellaneous					
Surface Coatings	5.8	6.3	6.4	6.4	6.5
Fuel Marketing	4.6	4.2	4.0	4.1	4.2
Dry Cleaning	0.6	0.6	0.6	0.6	0.6
Solvent Use	11.3	11.8	12.0	12.0	12.0
Slash Burning	1.0	1.4	1.5	1.8	2.0
Other	0.6	0.7	0.7	0.7	0.7
Power Generation	0.4	0.4	0.4	0.4	0.4
T O T A L	71.0	65.2	60.2	58.3	59.8

NO_x/VOC EMISSION FORECAST 90-A

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: \Saskatchewan

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	17.3	15.9	12.5	10.2	10.7
Light-Duty Trucks					
Gas	13.4	8.7	6.5	5.8	6.0
Diesel	0.1	0.2	0.2	0.2	0.3
Heavy-Duty Trucks					
Gas	3.1	1.1	0.6	0.5	0.5
Diesel	2.6	2.3	2.5	3.0	3.8
Off-Road Gasoline	10.2	9.1	8.6	9.0	9.8
Other	6.0	5.7	6.0	6.5	7.0
Fuel Combustion					
Fuelwood	2.3	2.1	2.2	2.3	2.2
Residential/Commercial	0.3	0.2	0.2	0.2	0.2
Industrial	0.1	0.1	0.1	0.1	0.1
Industrial Processes					
Petrochemicals	-	-	-	-	-
Petroleum Refining	1.7	1.6	1.5	1.6	1.8
Plastics	0.1	0.1	0.1	0.1	0.1
Crude Oil	1.9	2.3	2.5	2.6	2.5
Other	0.4	0.4	0.5	0.6	0.7
Incineration/Miscellaneous					
Surface Coatings	5.1	5.4	5.5	5.5	5.4
Fuel Marketing	4.5	4.0	3.7	3.9	4.2
Dry Cleaning	0.6	0.6	0.7	0.7	0.7
Solvent Use	10.8	11.5	12.0	12.4	12.8
Slash Burning	1.7	2.8	3.2	3.6	4.1
Other	0.4	0.4	0.5	0.5	0.5
Power Generation	0.3	0.3	0.3	0.3	0.3
T O T A L	83.9	74.8	69.9	69.6	73.7

NO_x/VOC EMISSION FORECAST 90-A

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: Alberta

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	50.4	34.1	25.6	21.8	22.1
Light-Duty Trucks					
Gas	16.1	15.0	11.4	9.8	10.0
Diesel	0.2	0.2	0.2	0.3	0.4
Heavy-Duty Trucks					
Gas	3.9	1.9	1.1	0.9	1.0
Diesel	3.6	3.7	3.4	3.5	3.9
Off-Road Gasoline	16.9	15.4	14.8	15.4	15.9
Other	12.1	11.7	12.1	12.8	14.0
Fuel Combustion					
Fuelwood	1.5	1.5	1.6	1.7	1.7
Residential/Commercial	1.0	0.9	0.9	1.0	0.9
Industrial	5.3	5.1	5.7	5.9	5.8
Industrial Processes					
Petrochemicals	44.4	46.1	57.8	77.1	105.1
Petroleum Refining	5.3	5.5	5.7	6.0	6.3
Plastics	0.7	0.8	1.1	1.3	1.5
Crude Oil	10.5	10.0	11.2	11.5	11.2
Other	0.5	0.6	0.7	0.8	0.9
Incineration/Miscellaneous					
Surface Coatings	10.7	11.1	11.2	11.5	12.0
Fuel Marketing	12.9	11.7	11.1	11.5	11.8
Dry Cleaning	1.3	1.3	1.4	1.4	1.4
Solvent Use	24.8	25.0	25.8	26.5	27.1
Slash Burning	5.1	7.6	8.8	9.9	11.3
Other	1.4	1.5	1.6	1.6	1.8
Power Generation	0.6	0.6	0.6	0.6	0.6
T O T A L	229.2	211.3	213.8	232.8	266.7

NO_x/VOC EMISSION FORECAST 90-A

VOLATILE ORGANIC COMPOUNDS (VOCs)

PROVINCE: British Columbia

KILOTONNES (as total non-methane hydrocarbons)

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	58.3	52.2	41.5	35.9	35.5
Light-Duty Trucks					
Gas	26.3	19.3	15.4	13.7	14.2
Diesel	0.2	0.4	0.4	0.5	0.6
Heavy-Duty Trucks					
Gas	6.9	2.6	1.5	1.2	1.2
Diesel	5.2	4.2	4.1	4.4	4.9
Off-Road Gasoline	5.2	5.2	5.2	5.4	5.7
Other	11.7	13.3	14.5	15.3	17.0
Fuel Combustion					
Fuelwood	3.8	4.3	4.5	4.6	5.0
Residential/Commercial	0.3	0.3	0.3	0.3	0.3
Industrial	42.7	39.2	44.4	49.3	55.8
Industrial Processes					
Petrochemicals	1.6	1.7	2.0	2.2	2.6
Petroleum Refining	6.3	6.5	6.4	6.5	6.9
Plastics	0.7	0.9	1.1	1.4	1.6
Crude Oil	0.4	0.4	0.5	0.5	0.5
Other	6.0	7.1	9.9	11.2	11.7
Incineration/Miscellaneous					
Surface Coatings	21.5	22.6	23.7	24.4	25.2
Fuel Marketing	12.4	11.6	11.0	11.0	11.4
Dry Cleaning	1.6	1.7	1.7	1.8	1.8
Solvent Use	30.3	32.0	33.1	33.8	34.3
Slash Burning	43.9	40.2	45.4	50.5	57.4
Other	9.1	8.2	9.2	10.2	11.5
Power Generation	0.3	0.3	0.3	0.3	0.3
T O T A L	294.7	274.2	276.1	284.4	305.4

NO_x/VOC EMISSION FORECAST 90-A — **VOLATILE ORGANIC COMPOUNDS (VOCs)**

PROVINCE: Yukon/North West Territories — **KILOTONNES (as total non-methane hydrocarbons)**

SECTOR	1985	1990	1995	2000	2005
Transportation					
Cars	0.7	0.6	0.5	0.4	0.4
Light-Duty Trucks					
Gas	1.1	0.8	0.6	0.6	0.6
Diesel	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Heavy-Duty Trucks					
Gas	0.3	0.1	0.1	0.1	0.1
Diesel	0.3	0.2	0.2	0.2	0.2
Off-Road Gasoline	0.4	0.4	0.4	0.4	0.4
Other	1.0	1.0	1.1	1.2	1.2
Fuel Combustion					
Fuelwood	1.3	1.5	1.6	1.6	1.7
Residential/Commercial	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Industrial	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Industrial Processes					
Petrochemicals	-	-	-	-	-
Petroleum Refining	-	-	-	-	-
Plastics	-	-	-	-	-
Crude Oil	0.2	0.5	0.7	1.1	1.7
Other	-	-	-	-	-
Incineration/Miscellaneous					
Surface Coatings	0.3	0.3	0.3	0.3	0.4
Fuel Marketing	0.3	0.3	0.3	0.3	0.3
Dry Cleaning	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Solvent Use	0.8	0.9	0.9	0.9	0.9
Slash Burning	0.1	0.1	0.1	0.1	0.1
Other	< 0.1	< 0.1	< 0.1	< 0.1	0.1
Power Generation	0.2	0.2	0.2	0.2	0.2
T O T A L	7.0	6.8	7.0	7.4	8.3

APPENDIX B

AIR QUALITY OBJECTIVES

TABLE 1.2
CURRENT AND RECOMMENDED (a) NATIONAL AMBIENT AIR QUALITY OBJECTIVES AND CRITICAL LEVELS FOR OXIDANTS (OZONE), NITROGEN DIOXIDE, AMMONIA AND SULPHUR DIOXIDE

	AIR QUALITY OBJECTIVES			CRITICAL LEVELS (e)		
Contaminant	Current Air Quality Objectives	Recommended Air Quality Objectives	Exposure Period	Exposure (duration in hours)	Concentrations ug/m3	ppm
Oxidants (Ozone)						
maximum desirable levels	30 ug/m3 (0.015 ppm)	b	24-hour	0.5	300	0.150
	100 ug/m3 (0.05)	100 ug/m3 (0.05 ppm)	1-hour	1.0	150	0.075
maximum acceptable levels	50 ug/m3 (0.025 ppm)	b	24-hour	2.0	110	0.055
	160 ug/m3 (0.08 ppm)	160 ug/m3 (0.08 ppm)	1-hour	4.0	80	0.040
	30 ug/m3 (0.015 ppm) (c)	b	annual	8.0	60	0.030
		64 ug/m3 (0.032 ppm)(d)	seasonal mean	Vegetation/Growing Period (Average of 7-hour mean/day, 9 a.m. to 4 p.m.)	50	0.025
maximum tolerable levels	300 ug/m3 (0.15 ppm)	400 ug/m3 (0.2 ppm)	1-hour			
Nitrogen Dioxide						
maximum desirable levels	60 ug/m3 (0.03 ppm)	60 ug/m3 (0.03 ppm)	annual			
maximum acceptable levels	100 ug/m3 (0.05 ppm)	100 ug/m3 (0.05 ppm)	annual	annual	30 ug/m3[f]	
	200 ug/m3 (0.11 ppm)	b	24-hour			
	400 ug/m3 (0.21 ppm)	400 ug/m3 (0.21 ppm)	1-hour	4-hour	95 ug/m3[f]	
maximum tolerable levels	300 ug/m3 (0.16 ppm)	b	24-hour			
	1000 ug/m3 (0.53 ppm)	1000 ug/m3 (0.53 ppm)	1-hour			
Ammonia	No air quality objectives			monthly	100 ug/m3 (0.14 ppm)	
				24-hour	600 ug/m3 (0.86 ppm)	
				1-hour	10,000 ug/m3 (14.3 ppm)	
Sulphur Dioxide						
maximum desirable levels	30 ug/m3 (0.01 ppm)	30 ug/m3 (0.01 ppm)	annual			
	150 ug/m3 (0.06 ppm)	150 ug/m3 (0.06 ppm)	24-hour			
	450 ug/m3 (0.17 ppm)	450 ug/m3 (0.17 ppm)	1-hour			
maximum acceptable levels	60 ug/m3 (0.02 ppm)	60 ug/m3 (0.02 ppm)	annual	annual	30 ug/m3[g]	
	300 ug/m3 (0.11 ppm)	300 ug/m3 (0.11 ppm)	24-hour			
	900 ug/m3 (0.34 ppm)	900 ug/m3 (0.34 ppm)	1-hour	4-hour	95 ug/m3[g]	
maximum tolerable levels	800 ug/m3 (0.3 ppm)	800 ug/m3 (0.3 ppm)	24 hour			

(a) Recommendations have been made by the CCREM Federal-Provincial Advisory Committee on Air Quality to the Federal Department of the Environment.
(b) The recommendation is to rescind the current objective.
(c) There currently is no seasonal objective for ozone.
(d) A maximum acceptable level seasonal mean is recommended to prevent significant injury to the most susceptible vegetation during the peak growing months. The recommended level is near the levels occurring at the ground in rural areas due to natural sources of ozone.
(e) ECE draft critical levels.
(f) Nitrogen dioxide in combination with sulphur dioxide and ozone, as oxides of nitrogen are never found in isolation in the atmosphere.
(g) For sulphur dioxide acting alone.

TABLE 1.3

CANADIAN* AIR QUALITY REQUIREMENTS

	NITROGEN DIOXIDE (micrograms per cubic metre of ambient air)			OZONE (micrograms per cubic metre of air)		
	ANNUAL MEAN	24-HOUR AVERAGE	1-HOUR AVERAGE	ANNUAL MEAN	24-HOUR AVERAGE	1-HOUR AVERAGE
NATIONAL						
maximum desirable level	60				30	100
maximimum acceptable level	100	200	400	30	50	160
maximum tolerable level		300	1000			300
BRITISH COLUMBIA						
Level A						
Level B						
Level C						
ALBERTA						
maximum permissible concentrations	60	200	400		50	160
SASKATCHEWAN						
present standard	100	200	400		30	100
proposed standard					50	160
MANITOBA						
maximum desirable level	60				30	100
maximum acceptable level	100	200	400	30	50	160
maximum tolerable level			1000			400
ONTARIO						
ambient air criteria		200	400			165
QUEBEC						
ambient air standard	103	207	414			157
Montreal Urban Community standard **	100	200	400			
NEW BRUNSWICK						
maximum permissible ground level concentration	100	200	400			
NOVA SCOTIA *						
PRINCE EDWARD ISLAND						
NEWFOUNDLAND						
acceptable criteria		200	400	30	50	160

* Prince Edward Island, the Northwest Territories and the Yukon Territory do not have air quality requirements specific to their jurisdictions.

** The Montreal Urban Community also has an 8-hour standard of 253 ug/m^3.

*** Nova Scotia uses the National Ambient Air Quality Objectives but has not legally adopted them.

APPENDIX C

EXISTING NOX/VOC REGULATIONS

Tables 2-1, 2-2, 2-3, and 2-4 summarize the existence of emission standards for various sources of NO_x and VOC. Further details are provided in the Work Sub-Group reports and related literature.

Although the information presented should be confirmed with the responsible regulatory authorities, Tables 2 do provide a preliminary overview of the existence of emission standards for various NOx and VOC sources, in Canada and other countries. (Blanks in the tables indicate that no known emission standards existed for that source or jurisdiction.)

CONTROL TECHNOLOGIES FOR MANAGEMENT OF NITROGEN OXIDES (NO_x) AND VOLATILE ORGANIC COMPOUNDS (VOC) IN CANADA

Table 2.1.1a - Status of Emissions Standards - Canada
New Mobile Sources - NOx, VOC

Source	CAN	OTHER		NOTES
■ Gasoline Fuel	R (1)		(1)	Environment Canada Lead in Gasoline-Lower Level announced Can. Gazette Part 1, July 15, 1989.
■ Diesel Fuel	R (2)		(2)	Environment Canada Sulphur in Diesel limitation - Expected announcement Can. Gazette, Part 1, Sept, 1990.
■ Light Duty Gasoline Vehicle (LDGV)	R (3)		(3)	Transport Canada-Current standards in effect Sept 1, 1987.
■ Heavy Duty Vehicles (HDV)	R (4)		(4)	Transport Canada-Current standards in effect Dec 1, 1988.
■ Heavy Duty Diesel Vehicle (HDDV)	R (5)		(5)	Transport Canada-more stringent regulation contingent on Environment Canada sulphur in diesel limits (2). Sulphur in diesel affects particulate control systems.
■ Off-Road Diesel Equip. (Farm, Construction etc.)	(6)		(6)	Legislative authority required to regulate.
■ Miscellaneous Gasoline Engines	(6)		(6)	
■ Stationary Reciprocating Engines-Diesel	(7)	(7)	(7)	Legislative authority required. Some provinces may regulate.
■ Natural Gas Turbines	(8)	(8)	(8)	Legislative authority required. Some provinces provinces may regulate, e.g. Alberta.
■ Rail, Marine Aircraft	(9)		(9)	Legislative authority required to regulate. Transport Canada does not have authority now to impose International Civil Aircraft Organization (ICAO) standards.

*See Table 2.1.1b for In-Use Vehicle Standards

LEGEND

R - Regulation

( ) - Note Number

CONTROL TECHNOLOGIES FOR MANAGEMENT OF NITROGEN OXIDES (NO_x) AND VOLATILE ORGANIC COMPOUNDS (VOC) IN CANADA

Table 2.1.1b - Status of Emission Standards - Canada
In-Use Vehicles

Province	NFLD	PEI	NS	NB	QUE	ONT	MAN	SASK	ALTA	BC	YUK	NWT
EMISSION CONTROL EQUIPMENT												
Anti-Tampering Legislation	Y	N	N	P	Y	Y	N	N	N	Y	I	I
Possible Date				1990								
Idle Emissions Specifications	N	N	N	N	N	Y	N	N	N	##	N	N
Aftermarket Catalyst Legislation	N	N	N	I	N	Y	N	N	N	I	N	N
Enforcement Program												
Annual I/M	N	N	N	I	N	I#	N	N	I	P	N	N
Spot Check	N	N	N		N	Y	N	N	N	P	N	N
On Resale	N	N	N		N	P*	N	N	N	I	N	N
Possible Date			?	?		#93/95 *90				90/91		
Anti-Misfuelling Legislation	Y	N	I	I	N	Y	N	N	N	N	N	N
INLET RESTRICTOR												
Legislation	Y	N	N	P	Y	Y	N	N	N	N	N	N
Enforcement Program	N	N	N	I	N	S	N	N	N	I	N	N
NOZZLE Tampering												
Legislation	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N
Enforcement Program	S	S	Y	Y	Y	Y	N	L	N	L	N	N
VISIBLE OR SMOKE Emissions Legislation												
LDV	N	N	?	Y	Y	Y	Y	Y	N	N	?	N
HDV	N	N	N	Y	Y	Y	Y	Y	N	Y	N	N
Enforcement Program	N	N	N	N	L	L	?	**	N	L	N	N
SAFETY CHECK												
Existing Leg.	Y	Y	Y	Y	Y	Y	Y	?	I	(C)	Y	N
Enforcement Program												
On Resale			N		N	Y	N	N	N	N	N	N
Spot Checks					Y	Y	Y	N	N	(C)	(C)	N
Annual	Y	Y	Y	Y	N	N	N	***	I	(C)	N	L
GASOLINE QUALITY												
CGSB Standards	N	Y	Y	N	N	Y	N	F	Y	F	F	N
Other	I				Y		Y			N		Y
RVP Standards	I		I	P		Y		F		I		

LEGEND:

Y - Yes
I/M - Inspection Maintenance

Y = Yes
P = Planned
? = Unknown at this time
R = Regulation

N = No
S = Spot Checks

I = Investigating
L = Limited Program
(C) = Commercial Vehicle only
( ) = Note Number

** = has never been applied to mobile sources
*** = program discontinued in 1984
F = Industry Reported to Follow Canadian Government Standards Board
= No idle specs., but list federal test standards in legislation.

CONTROL TECHNOLOGIES FOR MANAGEMENT OF NITROGEN OXIDES (NO_x) AND VOLATILE ORGANIC COMPOUNDS (VOC) IN CANADA

Table 2.1.2 - Status of Emission Standards - International Mobile Sources - NOx, VOC

Source	USA	CALIF.	OTHER	NOTES	
■ Gasoline Fuel	R	R		(1)	Regulations of the U.S. Environmental Protection Agency (EPA) will influence all vehicles manufactured in USA and Canada. Generally California standards are move stringent than EPA standards.
■ Diesel Fuel	R(5)			(2)	Generally, European vehicle emissions standards are currently less stringent than North American requirements.
■ Light Duty gasoline Vehicles (LDGV)	R(1)	R(1)		(3)	Technical and economic feasibility studies are being conducted by California and EPA. Regulations for off-road diesels and other sources are expected.
■ Heavy Duty Gasoline Vehicles (HDGV)	R(1)	R(1)		(4)	The International Civil Aircraft Organization (ICAO) has noise and emission standards. Only the noise standards have been adopted as regulations by Canada.
■ Off-Road Diesel Equipment	D(3)	D(3)			
■ Stationary Reciprocating Engines-Diesel					
■ Gas Turbines					
■ Rail, Marine Aircraft				(5)	EPA limits diesel sulphur in fuel to 0.05percent by 1994.

LEGEND:

R - Regulation, D-Regulation being developed
G - Guideline

CONTROL TECHNOLOGIES FOR MANAGEMENT OF NITROGEN OXIDES (NO_x) AND VOLATILE ORGANIC COMPOUNDS (VOC) IN CANADA

Table 2.2.1 - Status of Emission Standards - Canada Stationary Sources - NOx

Sources	CAN	NFLD	PEI	NS	NB	QUE	ONT	MAN	SASK	ALTA	BC	NWT	YUK
■ Electric Utility Boiler	G(1)	P(2)	P	P	P	R,P	R,C,P (3)	P	G,P (4)	G,P (4)	R,P		
■ Industrial Boilers	R(5)	P	P	P	P	P	P	P	P	P	P,G (6)		
■ Combustion Turbines (7)						P	P	P	P	P	P		

LEGEND:

R - Regulation; G - Guideline; P - Site-specific permit; C - Total emission cap

Table 2.2.1 - Notes

(1) Environment Canada issued Guidelines (1981) for NOx, SO_2 and particulates. It is expected that NOx emission levels will be lowered, to reflect performance of current technologies.

(2) Most provinces have site-specific permitting systems, but many do not have uniform or minimum emission standards.

(3) Ontario has imposed "caps" on utility SO_2 and NOx emissions.

(4) Alberta and Saskatchewan have regulatory requirements for new utility boilers which are similar to Environment Canada guidelines (1).

(5) Regulation for boilers at federal facilities (expected summer 1990), are being developed under the Canadian Environmental Protection Act, Part IV.

(6) British Columbia is developing emission guidelines for industrial boilers which will be applied to site-specific permits. (expected summer 1990).

(7) Some gas turbine manufacturers are voluntarily adopting California emission standards.

CONTROL TECHNOLOGIES FOR MANAGEMENT OF NITROGEN OXIDES (NO_x) AND VOLATILE ORGANIC COMPOUNDS (VOC) IN CANADA

Table 2.2.2 - Status of Emission Standards - International (0) Stationary Sources - NOx

Sources	USA	CALIF.	EUR	FRG	JAP	NOTES
■ Electric Utility Boilers	R(1)	R(2)	R(3)	R(4)	R(5),P	(1) (2)
■ Industrial Boiler	R(6)	R	R(3)	R(4)	R(5)P,	
■ Combustion Turbines	R	(6)				

LEGEND:

R - Regulation, P - Site-specific permit

Table 2.2.2 - Notes

(1) US Environmental Protection Agency promulgated New Source Performance Standards (NSPS), (1977), for NOx, SO_2 and particulates. Under proposed amendments to the Clear Air Act, proposed in Summer 1989, reductions of SO_2 and NOx emissions from existing sources, are expected.

(2) California South Coast Air Quality regulations, in effect, prevent the use of coal or oil in utility boilers.

(3) The European Community Ordinance for Large Furnaces, applies to all boilers over 100 MW (thermal).

(4)(5) Emissions standards in Southern California, the Federal Republic of Germany (FRG) and Japan are the world's, most stringent.

(6) Some gas turbine manufacturers are voluntarily adopting California emission standards.

CONTROL TECHNOLOGIES FOR MANAGEMENT OF NITROGEN OXIDES (NO_X) AND VOLATILE ORGANIC COMPOUNDS (VOC) IN CANADA

Table 2.3.1 - Status of Emission Standards - Canada Large Stationary Sources - VOC

Sources	CAN	NFLD	PEI	NS	NB	QUE	ONT	MAN	SASK	ALTA	BC	NWT	YUK	MUC
■ Crude Oil Production - Storage											G			
■ Petroleum - Storage - Equip Leak - Process					R(1)	R(2)	G			P(6) P(7)	G(8)			B(2)(4) B(3)
■ Gasoline Distribution - Storage - Serv. Stat. Deliveries - Vehicles Refuelling - Volatility Reduction					R(1) T	R(2) R	R(5)							B(2)(4) B(4)
■ Petrochemical & Organic Chem. - Storage - Equip Leak						R(2)	G			P(6) P(7)				B(2)(4)
■ Plastic Processing														
■ Pulp & Paper														
■ Wood Transformation														

LEGEND:

R - Regulation, G - Guideline, B - By-Law Montreal Urban Community, P - Site Specific Permit, T-Proposed Regulation

Table 2.3.1 - Notes

(1) NB regulation applies to tanks with capacity greater than 23.80 m^3 for liquids with true vapour pressure (TVP) greater than 10.3 kPa.

(2) Quebec and Montreal requirements apply to new tanks with capacity greater than 250 m^3 and TVP greater than 10kPa, and to existing tanks greater than 1500m^3 (or flow-through greater than 4,500m^3 for refineries) and TVP greater than 10kPa.

(3) Requires 90% reduction of asphalt Oxidation Emissions.

(4) Requires submerged loading for tank greater than 5m^3, storing Organic liquids.

(5) Gasoline volatility limited to 72kPa during summer 1989.

(6) In general applies to tanks over 15 m. diameter and with TVP greater than 21kPa.

(7) Requires an approved leak detection and repair program.

(8) Applies to petroleum product tanks having a capacity greater than 245 m^3 when the liquid TVP is greater than 10.5kPa.

CONTROL TECHNOLOGIES FOR MANAGEMENT OF NITROGEN OXIDES (NO_x) AND VOLATILE ORGANIC COMPOUNDS (VOC) IN CANADA

Table 2.3.2 - Status of Emission Standards - International Large Stationary Sources - VOC (7)

Sources	USA	CO	GA	IA	ME	MD	NJ	TX	WA	CA
■ Crude Oil Production										
■ Petroleum Refining										
- Storage	C(1)N	R	R	R	R	R	R	R(P)	R	R
- Equip Leak	C,N	R	R	R		R		R(P)	R	R
- Process	C,(2)N	R	R					R(P)	R	R
■ Others	C(3)N(P)	R	R					R(P)	R	R
■ Gasoline Distribution										
- Storage	C(4),N	R	R	R	R	R	R	R(P)	R	R
- Serv. Stat. Deliveries	C		R		R	R	R	R(P)	R	R
- Vehicle Refuelling	C							R(P)		R
- Volatility Reduction	R(5)				R(6)	R(P)(6)	R(6)	R(7)		R(6)
■ Organic Chemical Industry	C(1)									
- Storage	N	R	R	R		R	R	R(P)		R
- Equip Leak	C,N			R				R(P)		R
- Process	N							R(P)		
■ Natural Gas Production										
Equip. Leak	C,N			R				R(P)		R
■ Rubber Products	C,N		R							R
■ Pharma-ceutical	C,N		R					R(P)		

LEGEND:

C - Control Technique Guidelines (CTG)
N - New Source Performance Standard (NSPS)
R - Regulations
(P) - Proposed

State regulations when not otherwise specified, are roughly equivalent to U.S. EPA Guidelines and Standards.

Table 2.3.2 - Notes

(1) Some provisions for tanks > 151 m^3 with TVP $\geq$ 3.5 kPa, and others for tanks 75m^3 with TVP $\geq$ 27.6kPa.

(2) Control Technique Guidelines (CTG) for Vacuum producing systems.

(3) CTG for process unit turnaround and Waste Water Systems NSPS proposed for Waste Water Systems.

(4) CTG bulk plants and terminals, NSPS for Bulk terminals.

(5) 9.0 PSI to 10.5 PSI (62 to 72 kPa)depending on regions.

(6) Reduction to 9 PSI (62kPa) for May to September.

(7) European standards were being complied at time of report printing.

CONTROL TECHNOLOGIES FOR MANAGEMENT OF NITROGEN OXIDES (NO_x) AND VOLATILE ORGANIC COMPOUNDS (VOC) IN CANADA

Table 2.4 - Status of Emissions Standards - Canada International Miscellaneous Sources - VOC

Source	CAN	OTHER	NOTES
■ Paint Application			(1) General: Few Standards exist for the control of VOC's from the sources listed. (See 4.4)
■ Glue and Adhesive Application			California South Coast Air Management Board is developing stringent regulatory requirements.
■ Printing Inks			Other jurisdictions in the USA with ozone excedences are are expected to develop control programs, and will be influenced by the US EPA proposed Clean Air Act Amendments.
■ Industrial/ Commercial degreasing			Initiatives are also being developed in Europe to control VOC sources.
■ Dry Cleaning			
■ Consumer Products - Automobile - Household - Personal Use			
■ Pest Control			
■ General Solvent Use			
■ Misc. Industries			

APPENDIX D

AMBIENT AIR QUALITY DATA

No. of Hours > Acceptable AQO (0.082 ppm) - Atlantic

Station No.	City	Address	Loc.	1983	1984	1985	1986	1987	1988	Yrs. of Data	Avg. (83-88)	Avg. (86-88)
30117	Halifax	Bedford	U	0	1	0		1	0	5	0	1
30115	Halifax	Shearwater	U	0	0	0	3	3	0	6	1	2
40202	Saint John	Post Office	U	2	116	5	3	32	37	6	33	24
40203	Saint John	Forest Hill	U	8	352	162	3		41	5	113	22
30601	Fall River		R				3	16	7	3	9	9
	Sheffield Mills		R				6	15		2	11	8
	Lepreau		R				2	7	52	3	20	20
	Blissville		R					16	21	2	19	19
30501	Kejimkujic		R			1	1	5	61	4	17	22
Average				3	117	34	3	12	27		25	14

suspect data

Maximum Ozone and % Reduction Required to Achieve Max. Acceptable AQO (0.082 ppm) - Atlantic

Station No.	City	Address	Loc.	1983	1984	1985	1986	1987	1988	Avg. (83-88)	% Red. (83-88)	Avg. 86-88 (86-88)	% Red. (86-88)
30117	Halifax	Bedford	U	0.080	0.080	0.060		0.050	0.080	0.070	0%	0.065	0%
30115	Halifax	Shearwater	U	0.070	0.050	0.070		0.100		0.073	0%	0.100	18%
40202	Saint John	Post Office	U	0.080	0.160	0.090	0.080	0.100	0.100	0.102	19%	0.093	12%
40203	Saint John	Forest Hill	U	0.110	0.160	0.160	0.080		0.100	0.122	33%	0.090	9%
30601	Fall River		R				0.110	0.100	0.090	0.100	18%	0.100	18%
	Sheffield Mills		R				0.100	0.108		0.104	21%	0.104	21%
	Lepreau		R				0.080	0.084	0.113	0.092	11%	0.092	11%
	Blissville		R					0.104	0.100	0.102	20%	0.102	20%
30501	Kejimkujic		R			0.080	0.080	0.110	0.150	0.105	22%	0.113	28%
Average				0.085	0.113	0.092	0.088	0.095	0.105	0.097	16%	0.096	15%

Maximum Ozone (ppm) and % Reduction Required to Achieve Max. Acceptable AQO (0.082 ppm) - Ontario and Quebec

NAPS	Station No.	City	Address	R/U	1983	1984	1985	1986	1987	1988
	10001	Huron Park		R	0.112	0.125	0.101	0.107	0.121	0.127
60204	12008	Windsor	467 University	U	0.135	0.143	0.116	0.104	0.110	0.159
	13021	Merlin		R	0.121	0.087	0.092	0.091	0.126	0.133
61004	14064	Sarnia	Centennial Park	U	0.136	0.125	0.110	0.114	0.170	0.131
	14118	Mandaumin		R	0.097	0.130	0.114	0.108	0.134	0.146
	14119	Thedford		R	0.118	0.130	0.127	0.121	0.139	
60901	15001	London	King/Rectory	U	0.122	0.114	0.110	0.099	0.117	0.137
	15013	Parkhill		R	0.121	0.129	0.100	0.140	0.144	0.124
	18007	Tiverton		R	0.139	0.134	0.122	0.131	0.117	0.143
	22071	Simcoe		R	0.123	0.115	0.118	0.105	0.117	0.190
	22901	Long Point		R	0.136	0.130	0.135	0.124	0.132	0.189
61501	26029	Kitchener	Edna/Frederick	U	0.108	0.090	0.105	0.116	0.094	0.118
	27056	Niagara Falls	Allendale	U						0.139
	27037	St. Catharines	North/Geneva	U	0.115	0.113	0.092	0.091		0.132
	28028	Guelph		U/S				0.102	0.104	0.117
60512	29000	Hamilton	Elgin/Kelly	U	0.111	0.095	0.096	0.088	0.105	0.137
	29105	Hamilton	Nash Rd.	U			0.104	0.096	0.111	0.128
	29114	Hamilton	Vickers Rd.	U				0.094	0.114	0.131
60417	31104	Toronto	25 Bresdalbane	U	0.148	0.130	0.104	0.086	0.133	0.159
	31120	Toronto	Junction	U	0.153	0.120	0.107	0.097	0.149	0.178
60410	33003	Toronto	Lawrence/Kennedy	U	0.159	0.139	0.080	0.110	0.115	0.162
60413	35003	Etobicoke	Elmcrest Rd.	U	0.147	0.113	0.118	0.113	0.128	0.148
60403	35033	Etobicoke	Evans/Arnold	U	0.107	0.090	0.101	0.102	0.128	0.157
	44006	Burlington	Hwy 2	U	0.116	0.162	0.115	0.099	0.167	0.151
61602	44015	Oakville	Bronte Rd.	U	0.118	0.111	0.097	0.097	0.165	0.183
61701	45025	Oshawa	Ritson Rd.	U	0.158	0.085	0.115	0.112	0.137	0.185
60415	46110	Mississauga	Queensway W	U	0.153	0.111	0.104	0.103	0.141	0.177
	47035	Alliston		S	0.087	0.095	0.094	0.096	0.094	0.177
	48002	Stouffville		R/S	0.120	0.084	0.093	0.103	0.105	0.161
	49010	Dorset		R	0.101	0.089	0.080	0.089	0.098	0.117
60104	51001	Ottawa	Rideau/Wurt.	U	0.104	0.095	0.096	0.078	0.070	0.127
61201	58051	Cornwall		U	0.106	0.096	0.081	0.097	0.091	0.127
61103	59006	Peterborough		S		0.079	0.107	0.104	0.101	0.168
	75010	North Bay		S						0.109
	77203	Sudbury		S			0.117	0.104	0.089	0.113
50102		Montreal	Jardin Botanique	U	0.150	0.090	0.060	0.080		0.110
50103		Montreal	Pte. aux Trembles	U		0.100	0.160	0.110	0.100	0.130
50104		Montreal	1125 Ontario	U	0.170	0.080	0.080	0.080	0.100	0.110
50110		Montreal	Parc Plion	U	0.120		0.090	0.100	0.120	0.160
50112		Montreal	Boul. Laurentides	U	0.120	0.080	0.100	0.080	0.100	0.130
50113		Montreal	Pie X/Cardinal	U	0.140	0.100	0.100	0.100		0.130
50116		Montreal	Verdun	U	0.130	0.080	0.090	0.130	0.120	0.120
50119		Montreal	699 Cure Poirier	U		0.100	0.110	0.090		0.180
50120		Montreal	Roxboro	U						0.130
50306		Quebec	Blvd. St. Cyrille	U	0.100	0.070	0.110	0.100	0.070	0.140
50307		Quebec	Parc Cartier Breboeuf	U		0.060	0.160	0.070	0.060	0.080
51401		Ste. Etienne		R				0.120	0.120	
51501		St. Zephrini		R					0.100	0.150
51601		Ile d'Orleans		R					0.090	0.140
51701		St. Barnabe		R					0.130	0.150
Average					0.126	0.106	0.105	0.102	0.116	0.143
No. of Sites					35	38	41	44	43	48

Maximum Ozone (ppm) and % Reduction Required to Achieve Max. Acceptable AQO (0.082 ppm) - Ontario and Quebec

NAPS	Station No.	City	Address	R/U	1989	Yrs. of Data	Max	% Reduction (Maximum)	Average Max (83-88)
	10001	Huron Park		R	0.103	7	0.127	35%	0.114
60204	12008	Windsor	467 University	U	0.136	7	0.159	48%	0.129
	13021	Merlin		R	0.108	7	0.133	38%	0.108
61004	14064	Sarnia	Centennial Park	U	0.157	7	0.170	52%	0.135
	14118	Mandaumin		R	0.125	7	0.146	44%	0.122
	14119	Thedford		R		5	0.139	41%	0.127
60901	15001	London	King/Rectory	U	0.112	7	0.137	40%	0.116
	15013	Parkhill		R	0.115	7	0.144	43%	0.125
	18007	Tiverton		R	0.148	7	0.148	45%	0.133
	22071	Simcoe		R	0.093	7	0.190	57%	0.123
	22901	Long Point		R	0.135	7	0.189	57%	0.140
61501	26029	Kitchener	Edna/Frederick	U	0.096	7	0.118	31%	0.104
	27056	Niagara Falls	Allendale	U	0.109	2	0.139	41%	0.124
	27037	St. Catharines	North/Geneva	U	0.105	6	0.132	36%	0.108
	28028	Guelph		U/S	0.103	4	0.117	30%	0.107
60512	29000	Hamilton	Elgin/Kelly	U	0.127	7	0.137	40%	0.108
	29105	Hamilton	Nash Rd.	U	0.106	5	0.128	36%	0.109
	29114	Hamilton	Vickers Rd.	U	0.099	4	0.131	37%	0.110
60417	31104	Toronto	26 Bresdalbane	U	0.151	7	0.159	48%	0.130
	31120	Toronto	Junction	U	0.161	7	0.178	54%	0.138
60410	33003	Toronto	Lawrence/Kennedy	U	0.156	7	0.162	49%	0.132
60413	35003	Etobicoke	Elmcrest Rd.	U	0.187	7	0.187	56%	0.136
60403	35033	Etobicoke	Evans/Arnold	U	0.114	7	0.157	48%	0.114
	44008	Burlington	Hwy 2	U	0.165	7	0.167	51%	0.139
61602	44015	Oakville	Bronte Rd.	U	0.132	7	0.183	55%	0.129
61701	45025	Oshawa	Ritson Rd.	U	0.118	7	0.185	56%	0.130
60415	46110	Mississauga	Queensway W	U	0.126	7	0.177	54%	0.131
	47035	Alliston		S	0.109	7	0.177	54%	0.107
	48002	Stouffville		R/S	0.115	7	0.161	49%	0.112
	49010	Dorset		R		6	0.117	30%	0.096
60104	51001	Ottawa	Rideau/Wurt.	U	0.093	7	0.127	35%	0.094
61201	56051	Cornwall		U	0.130	7	0.130	37%	0.104
61103	59006	Peterborough		S	0.120	6	0.168	51%	0.113
	75010	North Bay		S	0.096	2	0.109	25%	0.103
	77203	Sudbury		S	0.095	5	0.117	30%	0.104
50102		Montreal	Jardin Botanique	U		5	0.150	45%	0.096
50103		Montreal	Pte. aux Trembles	U		5	0.160	49%	0.120
50104		Montreal	1125 Ontario	U		6	0.170	52%	0.103
50110		Montreal	Parc Pilon	U		5	0.160	49%	0.116
50112		Montreal	Boul. Laurentides	U		6	0.130	37%	0.102
50113		Montreal	Pie X/Cardinal	U		5	0.140	41%	0.114
50116		Montreal	Verdun	U		6	0.130	37%	0.112
50119		Montreal	699 Cure Poirier	U		4	0.180	54%	0.120
50120		Montreal	Roxboro	U		1	0.130	37%	0.130
50306		Quebec	Blvd. St. Cyrille	U		6	0.140	41%	0.098
50307		Quebec	Parc Cartier Breboeuf	U		5	0.160	49%	0.086
51401		Ste. Etienne		R		2	0.120	32%	0.120
51501		St. Zephrini		R		2	0.150	45%	0.125
51601		Ile d'Orleans		R		2	0.140	41%	0.115
51701		St. Barnabe		R		2	0.150	45%	0.140
Average					0.123		0.143	42%	0.117
No. of Sites					33		50		

Maximum Ozone (ppm) and % Reduction Required to Achieve Max. Acceptable AQO (0.082 ppm) - Ontario and Quebec

NAPS	Station No.	City	Address	R/U	% Reduction (Avg. Max)		Avg. of 3 Highest Max	% Reduction (Avg. 3 High Max.)
	10001	Huron Park		R	26%		0.124	34%
60204	12008	Windsor	467 University	U	36%		0.146	44%
	13021	Merlin		R	24%		0.127	35%
61004	14064	Sarnia	Centennial Park	U	39%		0.154	47%
	14118	Mandaumin		R	33%		0.137	40%
	14119	Thedford		R	35%		0.132	38%
60901	15001	London	King/Rectory	U	29%		0.125	35%
	15013	Parkhill		R	34%		0.138	40%
	18007	Tiverton		R	39%		0.143	43%
	22071	Simcoe		R	33%		0.143	43%
	22901	Long Point		R	41%		0.153	47%
61501	26029	Kitchener	Edna/Frederick	U	21%		0.113	27%
	27056	Niagara Falls	Allendale	U	34%		0.597	86%
	27037	St. Catharines	North/Geneva	U	24%		0.112	27%
	28028	Guelph		U/S	23%		0.108	24%
60512	29000	Hamilton	Elgin/Kelly	U	24%		0.125	34%
	29105	Hamilton	Nash Rd.	U	25%		0.115	29%
	29114	Hamilton	Vickers Rd.	U	25%		0.115	28%
60417	31104	Toronto	26 Bresdalbane	U	37%		0.153	46%
	31120	Toronto	Junction	U	41%		0.164	50%
60410	33003	Toronto	Lawrence/Kennedy	U	38%		0.159	48%
60413	35003	Etobicoke	Elmcrest Rd.	U	40%		0.161	49%
60403	35033	Etobicoke	Evans/Arnold	U	28%		0.133	38%
	44008	Burlington	Hwy 2	U	41%		0.161	49%
61602	44015	Oakville	Bronte Rd.	U	36%		0.155	47%
61701	48025	Oshawa	Ritson Rd.	U	37%		0.160	49%
60415	48110	Mississauga	Queensway W	U	37%		0.157	48%
	47036	Alliston		S	24%		0.127	36%
	48002	Stouffville		R/S	27%		0.132	38%
	48010	Dorset		R	14%		0.101	19%
60104	51001	Ottawa	Rideau/Wurt.	U	13%		0.109	25%
61201	58061	Cornwall		U	21%		0.108	24%
61103	59006	Peterborough		S	28%		0.132	38%
	75010	North Bay		S	20%		0.579	86%
	77203	Sudbury		S	21%		0.111	26%
50102		Montreal	Jardin Botanique	U	16%		0.117	30%
50103		Montreal	Pte. aux Trembles	U	32%		0.133	39%
50104		Montreal	1125 Ontario	U	21%		0.127	35%
50110		Montreal	Parc Pilon	U	31%		0.133	39%
50112		Montreal	Boul. Laurentides	U	19%		0.117	30%
50113		Montreal	Pie X/Cardinal	U	28%		0.123	34%
50116		Montreal	Verdun	U	27%		0.127	35%
50119		Montreal	699 Cure Poirier	U	32%		0.140	41%
50120		Montreal	Roxboro	U	37%			
50306		Quebec	Blvd. St. Cyrille	U	17%		0.117	30%
50307		Quebec	Parc Cartier Brebeouf	U	5%		0.103	21%
51401		Ste. Etienne		R	32%			
51501		St. Zephrini		R	34%			
51601		Ile d'Orleans		R	29%			
51701		St. Barnabe		R	41%			
Average					30%		0.152	39%
No. of Sites								

No. of Hours > Acceptable AQO (0.082 ppm) - Ontario and Quebec

NAPS	Station No.	City	Address	R/U	1983	1984	1985	1986	1987	1988
	10001	Huron Park		R	107	68	38	44	89	228
60204	12008	Windsor	467 University	U	116	139	77	39	70	223
	13021	Merlin		R	57	5	17	5	95	362
61004	14064	Sarnia	Centennial Park	U	116	80	47	30	44	125
	14118	Mandaumin		R	16	128	25	41	133	239
	14119	Thedford		R	16	79	92	44	80	
60901	15001	London	King/Rectory	U	72	24	31	14	34	174
	15013	Parkhill		R	61	63	16	57	158	204
	18007	Tiverton		R	87	42	86	31	167	331
	22071	Simcoe		R	182	122	71	53	119	354
	22901	Long Point		R	169	152	183	165	139	566
61501	26029	Kitchener	Edna/Frederick	U	57	6	27	33	21	172
	27037	St. Catharines	North/Geneva	U	116	19	19	11		123
	27056	Niagara Falls	Allendale Ave.	U						207
	28026	Guelph	Exhibition St.	U/S				24	75	138
60512	29000	Hamilton	Elgin/Kelly	U	61	7	17	5	24	144
	29105	Hamilton	Nash Rd.	U			23	11	69	99
	29114	Hamilton	Vickers Rd.	U			0	34	85	156
60417	31104	Toronto	26 Breadalbane	U	79	45	27	11	51	110
	31120	Toronto	Junction	U	118	50	18	36	81	112
60410	33003	Toronto	Lawrence/Kennedy	U	74	17	0	46	56	106
60413	35003	Etobicoke	Elmcrest Rd.	U	119	64	33	75	43	154
60403	35033	Etobicoke	Evans/Arnold	U	29	7	14	38	40	68
	44008	Burlington	Hwy 2	U	55	124	19	46	31	38
61602	44015	Oakville	Bronte Rd.	U	27	14	12	31	66	141
61701	45025	Oshawa	Ritson Rd.	U	101	2	42	20	41	138
60415	46110	Mississauga	Queensway W	U	38	10	13	17	25	108
	47035	Alliston		S	3	29	12	7	14	99
	48002	Stouffville		R/S		2	8	7	30	153
	49010	Dorset		R	20	20	0	8	41	121
60104	51001	Ottawa	Rideau/Wurt.	U	14	7	1	0	0	57
61201	56051	Cornwall		U	47	19	1	16	11	77
61103	59006	Peterborough		S		0	47	19	20	66
	75010	North Bay		S						119
	77203	Sudbury	Science North	S			45	8	5	91
50102		Montreal	Jardin Botanique	U	10	10	0	0		6
50103		Montreal	Pte. aux Trembles	U		2	24	27	12	24
50104		Montreal	1125 Ontario	U	26	0	0	0	2	51
50110		Montreal	Parc Pilon	U	17	0	2	8	20	142
50112		Montreal	Boul. Laurentides	U	44	0	3		3	89
50113		Montreal	Pie X/Cardinal	U	68	8	22	7		99
50116		Montreal	Verdun	U	36	0	3	6	15	95
50119		Montreal	699 Cure Poirier	U		20	23	2	1	157
50120		Montreal	Roxboro	U						70
50306		Quebec	Blvd. St. Cyrille	U	11	0	24	13		5
50307		Quebec	Parc Cartier Breboeuf	U		0	29	0	3	0
51401		Ste. Etienne		R				6	18	
51501		St. Zephrini		R					13	144
51601		Ile d'Orleans		R					1	
51701		St. Barnabe		R					23	50
Average					64	35	28	25	48	139

No. of Hours > Acceptable AQO (0.082 ppm) - Ontario and Quebec

NAPS	Station No.	City	Address	R/U	1989	Avg. 3 High Yrs	Average (1983 -1989)	Yrs of Data
	10001	Huron Park		R	49	141	89	7
60204	12008	Windsor	467 University	U	85	159	107	7
	13021	Merlin		R	77	178	88	7
61004	14064	Sarnia	Centennial Park	U	78	107	74	7
	14118	Mandaumin		R	21	167	86	7
	14119	Thedford		R		84	62	5
60901	15001	London	King/Rectory	U	67	92	59	7
	15013	Parkhill		R	61	142	89	7
	18007	Tiverton		R	106	201	121	7
	22071	Simcoe		R	39	219	134	7
	22901	Long Point		R	257	331	233	7
61501	26029	Kitchener	Edna/Frederick	U	16	87	47	7
	27037	St. Catharines	North/Geneva	U	10	86	50	6
	27056	Niagara Falls	Allendale Ave.	U	77		142	2
	28028	Guelph	Exhibition St.	U/S	37	83	69	4
60512	29000	Hamilton	Elgin/Kelly	U	64	90	46	7
	29105	Hamilton	Nash Rd.	U	39	69	48	5
	29114	Hamilton	Vickers Rd.	U	31	92	61	5
60417	31104	Toronto	26 Breadalbane	U	27	80	50	7
	31120	Toronto	Junction	U	77	104	70	7
60410	33003	Toronto	Lawrence/Kennedy	U	55	79	51	7
60413	35003	Etobicoke	Elmcrest Rd.	U	46	116	76	7
60403	35033	Etobicoke	Evans/Arnold	U	44	51	34	7
	44008	Burlington	Hwy 2	U	127	102	63	7
61602	44015	Oakville	Bronte Rd.	U	112	106	58	7
61701	45025	Oshawa	Ritson Rd.	U	80	106	61	7
60415	46110	Mississauga	Queensway W	U	69	72	40	7
	47036	Alliston		S	13	47	25	7
	48002	Stouffville		R/S	106	96	51	6
	49010	Dorset		R		57	35	6
60104	51001	Ottawa	Rideau/Wurt.	U	9	27	13	7
61201	58051	Cornwall		U	3	37	25	7
61103	59006	Peterborough		S	104	72	43	6
	75010	North Bay		S	36		78	2
	77203	Sudbury	Science North	S	15	50	33	5
50102		Montreal	Jardin Botanique	U		9	5	5
50103		Montreal	Pte. aux Trembles	U		25	18	5
50104		Montreal	1125 Ontario	U		27	14	6
50110		Montreal	Parc Pilon	U		60	32	6
50112		Montreal	Boul. Laurentides	U		45	28	5
50113		Montreal	Pie X/Cardinal	U		63	41	5
50116		Montreal	Verdun	U		49	26	6
50119		Montreal	699 Cure Poirier	U		67	41	5
50120		Montreal	Roxboro	U			70	1
50306		Quebec	Blvd. St. Cyrille	U		16	11	5
50307		Quebec	Parc Cartier Brebeuf	U		11	6	5
51401		Ste. Etienne		R			12	2
51501		St. Zephnni		R			79	2
51601		Ile d'Orleans		R			1	1
51701		St. Barnabe		R			37	2
Average					62	91	57	

Maximum Ozone (ppm) and % Reduction Required to Achieve Max. Acceptable AQO (0.082 ppm) - N. Ontario and Prairies

Station No.	City	1983	1984	1985	1986	1987	1988		Avg (83-88)	% Red. Average	Avg . of 3 High Max.	% Red. 3 High Max.
60602	Sudbury	0.150	0.070	0.080	0.090	0.090	0.110		0.098	17%	0.117	30%
60707	Sault Ste. Marie	0.090	0.070	0.070	0.060	0.090	0.090		0.078	0%	0.090	9%
60807	Thunder Bay	0.070	0.060		0.060	0.060	0.080		0.066	0%	0.070	0%
70118	Winnipeg	0.080	0.080	0.080	0.070	0.070	0.090		0.078	0%	0.083	2%
70119	Winnipeg	0.090	0.080	0.070	0.070	0.080	0.090		0.080	0%	0.087	5%
80110	Regina	0.100	0.100	0.080		0.050	0.100		0.086	5%	0.100	18%
80209	Saskatoon		0.070	0.060	0.060	0.060	0.060		0.062	0%	0.063	0%
90122	Edmonton	0.080		0.070	0.080	0.090	0.080		0.080	0%	0.083	2%
90130	Edmonton	0.060	0.090	0.090	0.090	0.070	0.070		0.078	0%	0.090	9%
90222	Calgary	0.080	0.090	0.080	0.080	0.080	0.090		0.083	2%	0.087	5%
90227	Calgary	0.070	0.070	0.070	0.070	0.060	0.070		0.068	0%	0.070	0%
Average		0.087	0.078	0.075	0.073	0.073	0.085		0.078	2%	0.085	7%

No. of Hours > Acceptable AQO (0.082 ppm) - N. Ontario and Prairies

Station No.	City	1983	1984	1985	1986	1987	1988	Yrs of Data	Avg (83-88)	Avg 3 High Years
60602	Sudbury	2	0	1	2	6	82	6	16	29
60707	Sault Ste. Marie	9	0	0	0	4	9	6	4	7
60807	Thunder Bay	0	0		0	0	0	5	0	0
70118	Winnipeg	0	0	0	0	0	4	6	1	1
70119	Winnipeg	2	1	0	0	0	1	6	1	1
80110	Regina	1	38	1		0	1	5	8	13
80209	Saskatoon		0	0	0	0	0	5	0	0
90122	Edmonton	2		0	1	8	1	5	2	3
90130	Edmonton	0	5	1	4	0	0	6	2	3
90222	Calgary	1	3	0	0	2	3	6	2	2
90227	Calgary	0	0	0	0	0	0	6	0	0
Average		2	5	0	1	2	9	6	3	5

No. of Hours > Acceptable AQO (0.082 ppm) - GVRD and Lower Fraser Valley

SITE	ADDRESS	LOC	1983	1984	1985	1986	1987	1988	1989	Average	Avg. of 3 High Years
T4	Kensington Park	EAST	0	1	0	0	0	10	0	2	4
T5	Confederation Park	EAST	0	2	8	2	1	16	3	5	9
T7	Anmore	EAST	7	1	16	13	4	31	0	10	20
T9	Rocky Point Park	EAST	36	12	36	11	2	39	3	20	37
T10	Eagle Ridge	EAST	7	9	7	16	0	34	4	11	20
T14	Burnaby Mountain	EAST		0	0	0	1	26	2	5	9
T21	Port Coquitlam	EAST					5	27	0	11	11
T24	Burnaby Lake	EAST				0	0	1	0	0	0
Avg.			10	4	11	6	2	23	2	8	14
T11	Abbotsford	RURAL		7	13	11	3	26	9	12	17
T12	Chilliwack	RURAL		8	16	1	12	13	4	9	14
T15	Surrey East	RURAL		11	29	0	4	26	0	12	22
T16	Pitt Meadows	RURAL			9	3	1	13		7	8
T25	Seymour Falls	RURAL	0	0	10	3	3	20	0	5	11
Avg.				7	15	4	5	20	3	9	14
T2	Kitsilano	WEST	1	0	0		0	1	2	1	1
T3	Marpole	WEST	0	0	0	0	0	0	0	0	0
T6	Second Narrows	WEST	0	4	0	0	0	0	2	1	1
T8	Lions Gate	WEST	0	2		0	0	2	0	1	1
T13	North Delta	WEST		0		0	0	0	0	0	0
T17	Richmond South	WEST				0	1	0	0	0	0
Avg.			0	1	0	0	0	1	1	0	1

Maximum Ozone (ppm) and % Reduction Required to Achieve Max. Acceptable AQO (0.082 ppm) - GVRD and Lower Fraser Valley

SITE	ADDRESS	LOC	1983	1984	1985	1986	1987	1988	1989		Average Max. (83-89)	% Red. Average		Avg. of 3 High Max.	%Red. 3 High Max.
T4	Kensington Park	EAST	0.075	0.084	0.076	0.085	0.082	0.105	0.075		0.080	0%		0.090	9%
T5	Confederation Park	EAST	0.077	0.089	0.094	0.095	0.085	0.105	0.094		0.091	10%		0.098	16%
T7	Anmore	EAST	0.113	0.089	0.107	0.121	0.092	0.156	0.073		0.107	24%		0.130	37%
T9	Rocky Point Park	EAST	0.169	0.106	0.124	0.131	0.084	0.149	0.101		0.123	34%		0.147	44%
T10	Eagle Ridge	EAST	0.096	0.109	0.105	0.133	0.082	0.167	0.096		0.113	27%		0.136	40%
T14	Burnaby Mountain	EAST		0.064	0.079	0.080	0.074	0.194	0.088		0.097	15%		0.116	30%
T21	Port Coquitlam	EAST					0.105	0.213	0.071		0.130	37%		0.130	37%
T24	Burnaby Lake	EAST				0.064	0.070	0.094	0.080		0.077	0%		0.084	2%
Avg.			0.108	0.090	0.098	0.098	0.084	0.148	0.085		0.102	18%		0.117	30%
T11	Abbotsford	RURAL		0.117	0.107	0.098	0.088	0.118	0.089		0.103	20%		0.114	28%
T12	Chilliwack	RURAL		0.122	0.107	0.084	0.099	0.104	0.098		0.102	20%		0.111	26%
T15	Surrey East	RURAL		0.116	0.110	0.072	0.084	0.159	0.078		0.103	21%		0.126	36%
T16	Pitt Meadows	RURAL			0.114	0.098	0.094	0.154	0.072		0.106	23%		0.122	33%
T25	Seymour Falls	RURAL	0.057	0.064	0.106	0.094	0.092	0.119	0.073		0.086	5%		0.106	23%
Avg.				0.105	0.109	0.089	0.091	0.131	0.082		0.100	18%		0.116	30%
T2	Kitsilano	WEST	0.101	0.075	0.082		0.069	0.084	0.083		0.082	0%		0.089	8%
T3	Marpole	WEST	0.057	0.060	0.068	0.062	0.069	0.080	0.079		0.068	0%		0.072	0%
T6	Second Narrows	WEST	0.063	0.093	0.070	0.045	0.054	0.089	0.075		0.067	0%		0.077	0%
T8	Lions Gate	WEST	0.068	0.092		0.060	0.074	0.087	0.058		0.073	0%		0.084	3%
T13	North Delta	WEST		0.053		0.059	0.054	0.081	0.065		0.062	0%		0.065	0%
T17	Richmond South	WEST				0.048	0.084	0.077	0.070		0.070	0%		0.077	0%
Avg.			0.072	0.075	0.073	0.056	0.067	0.080	0.072		0.070	0%		0.077	0%